NASA-SP-7020(02)

LUBRICATION, CORROSION and WEAR

A CONTINUING BIBLIOGRAPHY

WITH INDEXES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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NASA SP-7020(02)

LUBRICATION, CORROSION and WEAR

A CONTINUING BIBLIOGRAPHY

WITH INDEXES

A Selection of Annotated References to Unclassified Reports and Journal Articles Introduced into the NASA Information System during the period September, 1966–December, 1967.

Scientific and Technical Information Division
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. JULY 1968

INTRODUCTION

What *Lubrication, Corrosion and Wear* is

This publication is the second supplement to the continuing bibliography *Lubrication, Corrosion and Wear* (NASA SP-7020). It contains references to reports and journal articles announced in NASA abstract journals during the period September, 1966 through December, 1967. 754 references are included.

Previous bibliographies in this series are NASA SP-7020 (January 1962–March 1965) and NASA SP-7020(01) (April 1965–August 1966).

Scope of Bibliography

References are included for topics such as lubricating systems, design and performance of bearings; special applications of lubricants, e.g., as heat transfer and anticorrosion agents; stress corrosion and fatigue cracking in metals and alloys; friction and wear characteristics of materials; and corrosion types and techniques for corrosion prevention. In addition, references describing the instrumentation and methods for the testing of lubricants are included.

Organization of Bibliography

The bibliography is arranged in Abstracts and Index sections. The Abstracts section contains bibliographic citations and informative abstracts for the references selected from *STAR (Scientific and Technical Aerospace Reports), IAA (International Aerospace Abstracts),* and *Aerospace Medicine and Biology* (NASA SP-7011). The *STAR* abstracts are listed first, followed by the *IAA* abstracts and the *Aerospace Medicine and Biology* abstract. Each set of abstracts is arranged in ascending accession number order.

The Index Section contains two indexes, subject and personal author, in that order.

How to Use this Bibliography

Reports are referenced in the *STAR* Abstracts section. Published literature items are referenced in the *IAA* Abstracts and the *Aerospace Medicine and Biology* Abstracts sections. The subject index may be used to locate references to specific topics or technical areas; the personal author index may be used to locate references to reports or articles written by a particular individual.

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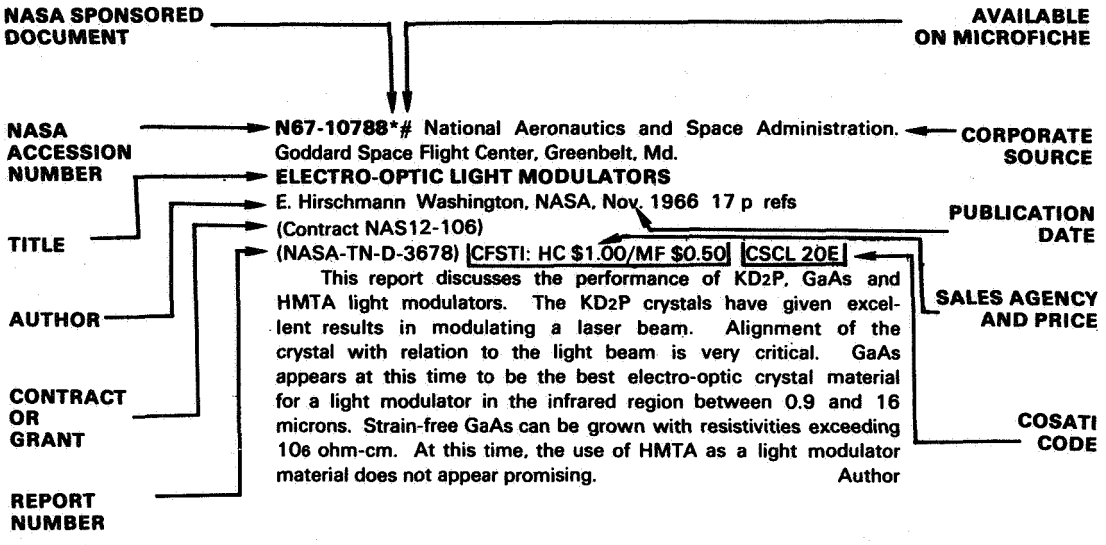
Aerospace Medicine and Biology References (A67-80000 Series)

Journal articles and books included in this section are available in libraries, where they may be borrowed or consulted.

TYPICAL *STAR* CITATION AND ABSTRACT



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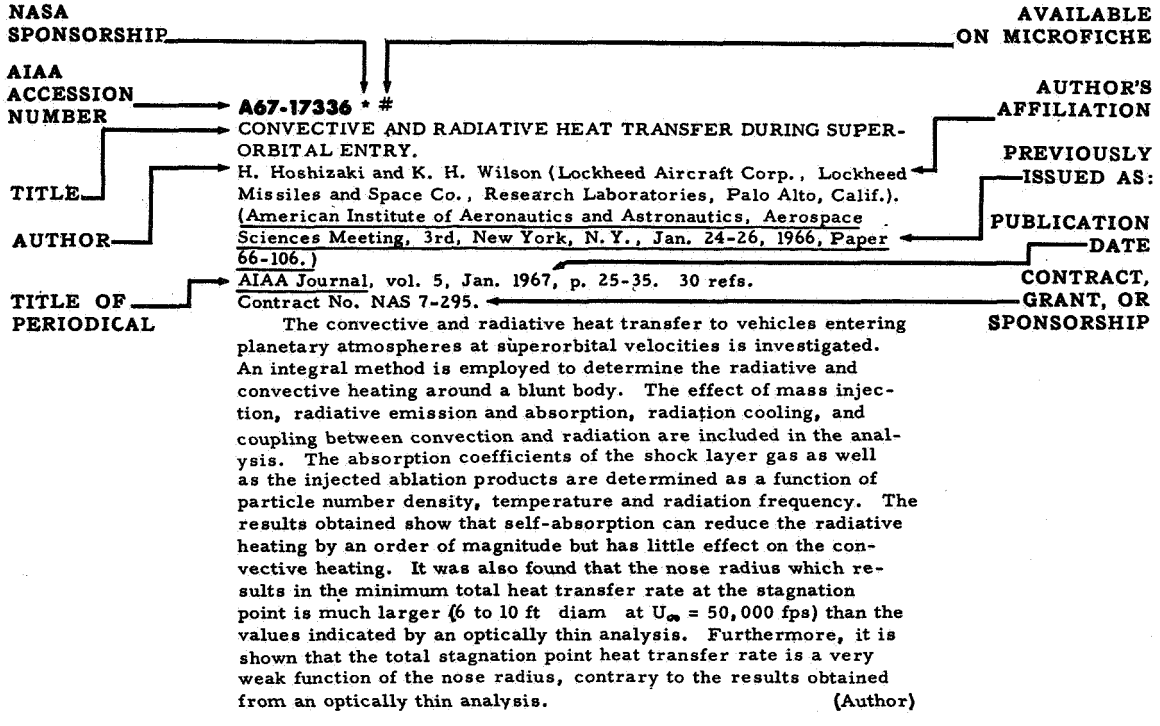

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LUBRICATION, CORROSION and WEAR

a continuing bibliography with indexes JULY 1968

1966

STAR ABSTRACTS

N66-32842# Bettis Atomic Power Lab., Pittsburgh, Pa.
THE CORROSION AND HYDROGEN PICKUP OF ELECTRON BEAM WELDED NICKEL-FREE ZIRCALOY-2 AND ZIRCALOY-4
S. Kass Mar. 1966 22 p refs
(Contract AT(11-1)-GEN-14)
(WAPD-TM-533) CFSTI: HC $1.00/MF $0.50

Corrosion tests with Zircaloy-4 and nickel-free Zircaloy-2 exhibiting large alpha grains formed by electron beam welding and annealing at 1450°F revealed that the large grain material does not corrode at rates significantly different from finer grained material, nor does the large grain material exhibit greater tendencies to absorb hydrogen than the finer grain materials. Author (NSA)

N66-32843# Bettis Atomic Power Lab., Pittsburgh, Pa.
THE EFFECT OF SILICON ON THE CORROSION AND HYDROGEN ABSORPTION CHARACTERISTICS OF ZIRCALOY-4 AND NICKEL-FREE ZIRCALOY-2
S. Kass Apr. 1966 21 p refs
(Contract AT(11-1)-GEN-14)
(WAPD-TM-544) CFSTI: HC $1.00/MF $0.50

The corrosion and hydrogen absorption chraracteristics of Zircaloy-2, Zircaloy-4, and nickel-free Zircaloy-2 containing added quantities of silicon were determined. Silicon additions caused no significant alterations in the 680°F corrosion resistance, but produced marked reductions in the tendencies for the alloys to absorb hydrogen during corrosion exposure. The hydrogen absorption characteristics were found to be dependent upon silicon contact and prior thermal treatment. Author (NSA)

N66-32872# Bettis Atomic Power Lab., Pittsburgh, Pa.
THE EFFECTS OF HEAT TREATMENT ON THE CORROSION AND HYDROGEN ABSORPTION CHARACTERISTICS OF A ZIRCONIUM-NIOBIUM-COPPER (ZR + 2.5% Nb + 0.5% Cu) ALLOY
S. Kass Mar. 1966 27 p refs
(Contract AT(11-1)-GEN-14)
(WAPD-TM-500) CFSTI: HC $2.00/MF $0.50

Corrosion tests in 600° and 680°F water and in high pressure steam at 750° and 950°F revealed that the Zr–2.5% Nb–0.5% Cu alloy possesses favorable corrosion characteristics. Optimum properties were obtained when the alloy was quenched from the alpha-plus-beta region and subsequently aged in the alpha region. Author (NSA)

N66-32889# General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.
STAINLESS STEEL FAILURE INVESTIGATION PROGRAM Quarterly Progress Report No. 3, Oct. 1–Dec. 31, 1965
R. N. Duncan, comp. Feb. 1966 40 p refs
(Contract AT(04-3)-189)
(GEAP-5085; EURAEC-1599) CFSTI: HC $2.00/MF $0.50

Corrosion tests on type 304 stainless steel in $HNO_3 - Cr^{6+}$ to determine the effect of high gamma radiation fields (~1,000 R) indicate that the presence of high energy gamma radiation does not increase the dissolution rate of the stainless steel. Results of 24 hr corrosion tests obtained previously on irradiated and unirradiated type 304 stainless steel in boiling $HNO_3 - Cr^{6+}$ are valid and indicate that irradiation exposure increases susceptibility to corrosion. The weight loss of irradiated cladding samples was consistently higher than that of unirradiated control specimens by a factor of two. Microthermoelectric measurements across grain boundaries in nonirradiated and irradiated stainless steel were completed and indicate no significant difference between the thermoelectric properties of grains and grain boundaries. A portable autoclave system was assembled and tested in preparation for corrosion tests on irradiated type 304 stainless steel samples in 650°F, 0.1 g/l iron chloride solutions. The various irradiated samples for these tests were prepared. Electrochemical studies at elevated temperatures, up to 275°C were initiated. Potentiostatic and intensiostatic curves were obtained for type 304 stainless steel samples in deionized water and in dilute iron chloride solutions. Variations due to scan speed, temperature and different electrolytes were observed. Author (NSA)

N66-32922*# SKF Industries, Inc., King of Prussia, Pa. Research Lab.
SUPERSONIC TRANSPORT LUBRICATION SYSTEM INVESTIGATION Third Semiannual Report, 1 Nov. 1965–1 May 1966
W. L. Rhoads and L. B. Sibley 20 May 1966 133 p refs
(Contract NAS3-6267)
(NASA-CR-54313; AL66T032) CFSTI: HC $3.00/MF $1.00 CSCL 13I

Ball bearings and bellows face seals for use on Mach 3 aircraft gas turbine engine mainshafts are being tested with several selected lubricants using both oil-mist and jet lubrica-

tion systems, with provisions for inert gas blanketing. Bearing operating temperatures of 600°F and higher are being explored under typical engine load and speed conditions with the seals exposed to 1200°F air and a pressure differential of 100 psi. Screening tests have proceeded in the recirculating rig with several candidate lubricants, and oil-mist testing has begun under heated conditions. Author

N66-32987# Joint Publications Research Service, Washington, D. C.

SPECIAL FEATURES OF PLASTIC FLOW AND FAILURE OF TITANIUM AT ROOM TEMPERATURE

I. A. Oding, V. S. Ivanova, and Ye. S. Kosyakina *In its* Mech. and Eng. Properties of Titanium Alloys 26 Jul. 1966 p 1-8 refs (See N66-32986 19-17) CFSTI: $6.00

Special features in the development of plastic flow and failure of titanium at room temperature are considered which distinguish it from other metals, including those with hexagonal close-packed lattice. High sensitivity to stress concentration and state of the surface is exhibited by titanium and its alloys, and high corrosion resistance is noted. Alpha-titanium is distinguishable from other hexagonal metals by a higher plasticity than would be expected by a metal with a CP-lattice. X-ray investigation reveals that the planes of the pyramid and prism of titanium are activated for slip at room temperature; and the high plasticity of titanium at room temperature is explained by the presence of several equiprobable sliding systems and several possible systems of twinning planes. These and other data indicate the complexity of realizing plastic flow when using statistical loads on the crystals of pure titanium. An electron microscope study of the plastic flow mechanism in a titanium alloy with sign variable bending shows that deformation takes place in various ways due to cyclical loading. The most probable mechanism for formation of the fault band in hexagonal metals is considered to be a dislocation. M.W.R.

N66-33011# Joint Publications Research Service, Washington, D. C.

THE POSSIBILITIES OF USING TITANIUM ALLOYS FOR SURGICAL INSTRUMENTS, APPARATUS AND TISSUE SPLICING AGENTS

N. F. Belavin and V. G. Shakhmatov *In its* Mech. and Eng. Properties of Titanium Alloys 26 Jul. 1966 p 203-207 refs (See N66-32986 19-17) CFSTI: $6.00

Data obtained from bending tests on several titanium alloys were compared with strength tests conducted with stainless martensitic steel 3Kh13. The results indicate that titanium alloys VT5-1, OT4-1, and VT14 have about the same strength when bending. The steel in the hardened state has somewhat greater strength and rigidity but cannot be used for insertion in an organism because of corrosion. An outline of a process used to put a nickel-phosphorus coating on titanium alloys to increase their wear resistance when used in surgical apparatus, is given. Some titanium alloy samples nickel plated by the procedure were tested for friction on a machine, and the results indicate that the coating does indeed increase the wear resistance. L.S.

N66-33302# Watervliet Arsenal, N. Y. Benét Labs.

PROCESS FOR ANODIZING TITANIUM

Theodore M. Pochily Apr. 1966 44 p refs

(WVT-6605; AD-633986) CFSTI: HC $2.00/MF $0.50

The requirements of an advancing technology in weaponry, aircraft, and aerospace have necessitated a consideration of light metals as a substitute for steel. In the search to reduce weight, and consequently increase mobility, titanium offers valuable assistance. The use of titanium as an engineering and structural material has been accepted for a comparatively short time. This acceptance was predicated on two important factors, strength/weight ratio and corrosion resistance. The tendency of titanium to gall and seize, when used as a bearing or mating surface, has restricted a full utilization of the metal. Work conducted at Watervliet Arsenal to develop a process that reduces or eliminates this condition was evaluated. Processing details, a summary of test data covering wear resistance, and the effects of the process on the mechanical properties of titanium are discussed. Author (TAB)

N66-33509# Coating and Chemical Lab., Aberdeen Proving Ground, Md.

TROPICAL EXPOSURE OF FINISHING SYSTEMS FOR FERROUS METALS Progress Report

Melvin H. Sandler May 1966 70 p refs

(CCL-197; AD-634156) CFSTI: HC $2.00/MF $0.75

The report covers a study on the corrosion protection afforded to ferrous metal under tropical exposure conditions by 28 paint systems covered by military standard 171 "Finishing of Wood and Metal Surfaces". Also included were 4 systems using an experimental epoxy primer and one with an experimental thermoset acrylic top coat. The coatings were applied over solvent cleaned steel, as well as metal pretreatments conforming to types I, II, and III of federal specification TT-C-490 "Cleaning Methods and Pretreatment of Ferrous Surfaces for Organic Coatings". Test specimens were exposed in the Panama Canal Zone at breakwater, open field, and rain forest sites. Another set was exposed concurrently at Aberdeen Proving Ground. After 21 months exposure test data showed zinc phosphate conforming to TT-C-490 type I to be the most effective pretreatment and that with the exception of control of corrosion in scribed areas at seacoast sites, many of the current finishing systems will provide a high degree of corrosion protection under various types of climatic exposure. The exact duration of this protection remains to be determined by additional long term exposure of the more effective systems. Author (TAB)

N66-33579# Rock Island Arsenal Lab., Ill. Research and Engineering Div.

LUBRICANT ADDITIVE EFFECTS UPON BEARING METAL FATIGUE. I: ROLLING CONTACT ADAPTATION FOR FOUR BALL EP TESTER

Max T. Fisher Apr. 1966 27 p refs

(RIA-66-1293; AD-634112) CFSTI: HC $2.00/MF $0.50

A rolling contact adaptation of the Four Ball Extreme Pressure Tester was devised and evaluated for its utility in determining the effects of additives in oils on the fatigue life of 52,100 steel balls. Six compounds, similar in molecular size to common additives but selected for different configurations and functional groups, were combined with low viscosity (80 SUS at 100° F) paraffinic and naphthenic oils in 5% concentrations. Their effects upon fatigue, compared with that of the oils alone, were determined. Molybdenum disulfide was also evaluated in the same manner. Based on fewer tests than statistically desirable, the 10% life taken from Weibull distribution plots of the results indicate that different additives and lubricant bases have varying effects upon the fatigue life of bearings. It appears that reasonably fast, economical and reliable ball bearing fatigue life results can be expected with this relatively inexpensive rolling contact adaptation of the widely used Four Ball EP Tester. Author (TAB)

N66-33644# Aluminum Co. of America, New Kensington, Pa. Chemical Metallurgy Div.

INVESTIGATION OF THE MECHANISM OF STRESS CORROSION OF ALUMINUM ALLOYS Final Report, Feb. 16, 1965–Feb. 16, 1966

J. Mc Hardy [1966] 127 p refs
(Contract NOw-65-0327-f)
(AD-633767)

The results suggest three stages in the stress corrosion process with the rate of penetration of corrosion or cracking increasing with each succeeding stage. In the first stage, stress corrosion takes place independently of stress, that is, it follows the same course as the general corrosion of an unstressed specimen; for the alloys investigated this general corrosion occurred as random pitting. In the second stage, the attack becomes intergranular (if not already of this type) and directional, and it leads to the development or cracks of a microscopic size, or larger; these are the secondary cracks frequently seen in specimens that faily by stress-corrosion cracking. The third stage initiates whenever one of the intergranular cracks developed in the second state progresses far enough for the yield strength of the specimen to be reached; and it continues to the point of tensile failure. Author (TAB)

N66-33673*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LUBRICANTS, BEARINGS, AND SEALS

Edmond E. Bisson, William J. Anderson, Robert L. Johnson, Erwin V. Zaretsky, and Lawrence P. Ludwig *In its* Selected Technol. for the Petrol. Ind. 1966 p 103–123 refs (See N66-33666 19-34) GPO: HC $1.25; CFSTI: MF $0.50

The influence of extreme environments on the operation of bearings and seals is described. The environments are extremely high or low temperature, vacuum, and contact with fluids chemically active toward the bearing and seal materials. Hydrodynamic and hydrostatic films, which separate surfaces in relative motion, are reviewed. Boundary lubrication films for use under contacting conditions, and solid lubricant films to provide low friction and surface protection are also mentioned. Rolling element bearings are discussed with respect to lubrication and fatigue. The advantages and disadvantages of gas bearing are identified, and various face contact seals are described. It was concluded that (1) solid lubricant coatings and built-in lubricants are satisfactory for limited life applications, and (2) for long-life operation, both bearings and seals require that their load-carrying surfaces be completely separated by fluid films. N.E.N.

N66-33716*# Midwest Research Inst., Kansas City, Mo.

SOLID LUBRICANTS Technology Survey

M. E. Campbell, John B. Loser and Eldon Sneegas Washington, NASA, May 1966 114 p refs Prepared for NASA
(NASA-SP-5059) GPO: HC $0.50; CFSTI: MF $0.75 CSCL 11H

Advantages, disadvantages, and the history of solid lubrication are briefly reviewed. Of the bonded types, resin bonded and inorganic bonded solid film lubricants are discussed. A listing of military and industrial specifications includes lubricants of the following types: molybdenum disulfide powder, grease, and oil; graphite; heat cured and air dried solid film; dry film ceramics; and silicon base. Development of several new lubricants by government agencies and industry is mentioned. The use of composites, powders, and plastics as lubricants is discussed. Friction and wear testing machinery is listed and evaluated. Among environmental effects on solid lubricants that are covered are normal and extreme atmospheric conditions, loading, temperature, and radiation. Applications of the in-situ process, electrophoretic deposition, and flame spraying are presented. The use of solid lubricants by the military services, the aerospace industry, and in commercial applications is pointed out. Tables, illustrations, and a detailed bibliography are included. K.W.

N66-33923# National Lead Co. of Ohio, Cincinnati. Technical Div.

EFFECT OF ENVIRONMENTAL CONDITIONS ON THE PITTING OF URANIUM

T. R. Kato and D. H. Price Dec. 1965 7 p refs
(Contract AT(30-1)-1156)
(NLCO-957) CFSTI: HC $1.00/MF $0.50

Corrosion pitting of uranium fuel cores during fabrication can be mitigated by controlling the environmental conditions under which they are produced. Mositure, chloride ion concentration, exposure time, and differential aeration were found to be especially important in the control of pitting. Author (NSA)

N66-33943# General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.

U.S.-EURATOM RESEARCH AND DEVELOPMENT PROGRAM Final Summary Report

D. L. Douglass Oct. 1965 87 p refs
(Contract AT(04-3)-189)
(GEAP-5001; EURAEC-1588) CFSTI: HC $3.00/MF $0.75

Transmission electron microscopy of the corrosion–oxidation films on Van Arkel Zr and Zircaloy-2, formed in air from 250° to 450°C and in water from 225° to 325°C, showed that gross differences existed in the film morphology depending upon the environment and surface preparation. Annealed Zr when oxidized in air formed monoclinic zirconia films that replicated the metal grain structure, but which also contained fine-grain regions, pseudo–amorphous areas, pustules, and preferentially oxidized grain boundaries. Etched Zr, oxidized under the same conditions, formed uniform films having only one heterogeneity, preferentially oxidized twins. Oxidation of annealed Zr in water produced a high density of oxide nuclei (monoclinic oxide) on a single crystal monoclinic matrix. Longer oxidation produced pustules that were much more numerous than those formed by air oxidation. Some pseudo–amorphous areas were also observed, but the pustules appeared more important, and grew laterally to form a completely coalesced overgrowth. Zircaloy-2 generally formed more uniform films than Zr in air and in water, and did not exhibit the preferential grain boundary oxidation so prevalent in Zr oxidation films. Annealed Zircaloy-2 formed mottled films, whereas, etched Zircaloy-2 similarly oxidized, showed unmottled grains that were sharply delineated and which clearly showed local areas corresponding to the intermetallics. The intermetallic compounds, which were selectively etched in the metal, gave rise to small white islands in the oxide films. These areas were found by electron diffraction to be nearly structureless. Transmission electron microscopy of detached oxidation films on Ti showed that thin films of rutile formed initially of uniform thickness and replicated the metal structure. The replicated metal grains, hereafter called oxide grains, were either polycrystalline on thermally etched facets of the metal, or were pseudo-monocrystalline and consisted of low angle boundaries and subgrains. Subsequently, an overgrowth of rutile nucleated on the oxide grains. The overgrowth of single-crystalline, heavily microtwinned oxide, grew laterally and enclosed islands of matrix oxide, as well as inwardly, and consumed the initial film. Complete coalescence resulted in single crystal oxide grains corresponding to each metal grain. Two networks could be distinguished by contrast variations

upon tilting. The first, which was most prevalent, nucleated within the oxide grains and only rarely crossed grain boundaries, whereas, the second nucleated at grain boundaries and grew across the grains. Oriented networks formed on faceted grains and grew along the faces rather than crossing ridges. Random networks were generally associated with pseudo-monocrystalline grains which formed on unfaceted metal grains. The characteristics of the matrix and the networks during heating are discussed, and the role of time and temperature on network nucleation and growth is considered. A few data points for oxygen–ion self-diffusion in UO_2 single crystals were obtained from 850 to 1000°C, but because of experimental difficulties, the reliability of the data is questionable. Author (NSA)

N66-33976*# General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.

ADVANCED REFRACTORY ALLOY CORROSION LOOP PROGRAM Quarterly Progress Report No. 4, Jan. 15–Apr. 15, 1966

R. W. Harrison, ed. 29 Apr. 1966 47 p

(Contract NAS3-6474)

(NASA-CR-72029) CFSTI: HC $2.00/MF $0.50 CSCL 11F

Results of work progress in a program directed toward fabricating, operating for 10,000 hrs, and evaluating a potassium corrosion test loop constructed of T-11 (Ta-8W-2H) alloy, are reported. Materials for evaluation in the turbine simulator include Mo-TZC and Cb-132M. Poor yields in the fabrication of the T-111 alloy have necessitated the melting of two additional ingots. Twenty nine lbs of lithium, which will be heated by direct resistance in a primary loop, were transferred to a hot trap. Analysis of the lithium after 126 hrs of hot trapping at 1500°F indicated an average nitrogen concentration of less than 8 ppm. Drawings of the alkali metal purification and handling system were submitted for approval. The results of a study to determine suitable welding conditions and post-weld annealing treatment for welds between Cb-1Zr alloy and T-11 alloy have indicated that the proposed joints between the Cb–1Zr surge tanks and T-11 fill lines of the Corrosion Loop I may be produced with manual TIG welding practices, if Cb-1Zr filler material and 2300–2400°F post weld annealing treatments are used. Other work relating to quality assurance and loop design are also discussed. L.S.

N66-34095# General Electric Co., Cincinnati, Ohio. Atomic Products Div.

PHYSICO-CHEMICAL STUDIES OF CLAD UO_2 IN POTENTIAL MELTDOWN ENVIRONMENTS

In its High-Temp. Mater. Programs, Pt. A 28 Feb. 1966 p 203–220 refs (See N66-34086 20-22) CFSTI: HC $6.00/MF $1.50

When heated at 0.3°C per second, Zircaloy in steam produces a three-layered structure consisting of an outer layer of ZrO_2, an intermediate layer of ZrO_{2-x} and an inner layer of metal. The intermediate layer contains tin or a tin-rich alloy which probably does not oxidize in steam because water is more stable than tin oxides at the temperatures used. Isothermal corrosion of Zircaloy with steam at temperatures of 1200 and 1400°C is approximately parabolic with time, and activation energy is calculated to be about 38 kcal/mole. At the relatively low heating rate of 0.3°C per second, Type 304 stainless may bloat upon melting after being subjected to water vapor corrosion and heated to melting point. Molten Zircaloy and UO_2 react relatively rapidly at temperatures of 1900°C and above; and upon cooling, the reaction products appear to be predominantly metal or a metallic phase in addition to ZrO_{2-x}. This reaction rate appears to be much slower than the Zircaloy steam oxidation reactions at similar temperatures. M.W.R.

N66-34194# Office of Naval Intelligence, Washington, D. C. Translation Section.

TECHNOLOGY OF MANUFACTURE AND PROPERTIES OF ANTIFRICTION MATERIALS CONTAINING FLUOROPLASTICS: BASIC PRINCIPLES OF PRODUCTION

A. P. Semenov, P. M. Matveyevskii, and V. V. Pozdnyakov [1966] 61 p ref Transl. into ENGLISH of the Book "Tekhnologiya Izgotovleniya i Svoystva Soderyashchikh Ftoroplast Antifriktsionnykh Materialov (Osnovnyye Printsypy Proizvodstva" Moscow, Izd. Akad. Nauk SSSR, 1963

(ONI-TRANS-2141; TT-66-61504; AD-634308) CFSTI: HC $3.00/MF $0.75

Contents: Comparative friction tests of various polymers with and without lubrication; Certain information on the physical, mechanical and technological properties of fluoroplastic-4 (polytetrafluoro ethylene); Possible means of utilizing the properties of fluoroplastic-4 developing antifriction materials and coatings; Survey of existing information on the use of fluoroplastic-4 in antifriction materials; Possible industrial procedures for manufacturing combines of antifriction materials containing fluoroplastic; Technological process of the manufacture of steel-porous bronze tape material impregnated with fluoroplastic; Comparison tests of various materials containing fluoroplastic; Conditions and possible fields of application of antifriction tape material containing polytetrafluoro ethylene. Author

N66-34612# Rock Island Arsenal Lab., Ill. Research and Engineering Div.

STATIC OUTDOOR EXPOSURE TESTS ON SOLID FILM LUBRICANT COATINGS Interim Report

George P. Murphy and Francis S. Meade May 1966 24 p refs

(RIA-66-1546; AD-635465) CFSTI: HC $1.00/MF $0.50

An investigation was made to: (1) determine the affect of several Rock Island Arsenal solid film lubricant formulations on the corrosion protection provided by several metal substrates and (2) determine the optimum solid film lubricant–substrate combination providing greatest corrosion protection. Conclusions obtained from the first series of tests are: (1) The solid film lubricant coating containing graphite decreased the corrosion protection provided by all the substrates and (2) The other solid film lubricant coating increased the corrosion protection provided by the zinc phosphatized substrate but did not substantially improve the corrosion protection provided by the other substrates. The limited exposure period to date of the second series of tests produced the following conclusions: (1) One solid film lubricant formulation greatly increased the corrosion protection provided by zinc phosphatized steel. (2) No corrosion has occurred on the remaining substrates coated with this formulation and (3) Increasing the lubricant film thickness greatly increases the corrosion protection provided by the lubricant. Author (TAB)

N66-34703*# Aluminum Co. of America, New Kensington, Pa. Physical Metallurgy Div.

STUDY OF CRACK INITIATION PHENOMENA ASSOCIATED WITH STRESS CORROSION OF ALUMINUM ALLOYS Literature Survey

M. S. Hunter, E. H. Hollingsworth, R. L. Horst, and John Mc Hardy 5 Aug. 1966 38 p refs

(Contract NAS8-20396)

(NASA-CR-77361) CFSTI: HC $2.00/MF $0.50 CSCL 11F

This survey encompassed 74 references to the literature on the phenomena of stress-corrosion cracks in metals, particularly aluminum aloys. Since most of the literature did not distinguish between the stages of initiation and propagation,

the survey is devoted to the whole process rather than to the initiation stage alone. Possible mechanisms and factors affecting stress-corrosion cracking are cited and environmental effects are assessed. H.S.W.

N66-34754# Southwest Research Inst., San Antonio, Tex. Dept. of Aerospace Propulsion Research.
FUNDAMENTAL INVESTIGATION OF LIQUID-METAL LUBRICATED JOURNAL BEARINGS Quarterly Technical Report No. 6
R. A. Burton and Y. C. Hsu 1 Mar. 1966 47 p refs
(Contract AT(11-1)-1228)
(SWRI-1228-8-20; RS-482) CFSTI: HC $2.00/MF $0.50

The calculated performance of finite tilting pad bearings is reported in terms of mean pressure and center-of-pressure location, as functions of length/width ratio, and tilt angle. The performance of a stepped pad is calculated by an iterative numerical program, and the pressure distribution is shown to resemble closely that measured experimentally. Interactions between a shear flow and pressure flows of different directions and magnitudes are investigated by application of the mixing length approach. Author (NSA)

N66-34821# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
INFLUENCE OF ALLOYING OF COPPER ON SEIZING IN CAPABILITY TEMPERATURES RANGE 23-450°
A. P. Semenov 12 Jan. 1966 26 p refs Transl. into ENGLISH from AN SSSR Inst. Mashinoved. Treniye Iznos v Mashinakh Sb. (Moscow), no. 15, 1962 p 227-253
(FTD-MT-65-28; AD-635278) CFSTI: HC $2.00/MF $0.50

To study more fully the influence of alloying on seizing capability and its connection with the mechanical properties of alloys, a study was made of a large number of copper alloys in the region of solid solutions. Seizing capability was determined according to joint plastic deformation of pairwise formed sheet samples by symmetrically slanted punches. Plotted curves represent the dependence of deformation magnitudes on pressures applied during deformation of the same samples by flat narrow punches. The results of the investigation confirm that for copper alloys the dissolution of alloying components and the change of crystal lattice parameter are important indices of antifriction properties. Probably, analogous dependences can also serve as leading principles for the evaluation and creation of antifriction alloys. TAB

N66-34824# Marine Engineering Lab., Annapolis, Md.
THE EFFECT OF MINOR ALLOYING ADDITIONS ON THE SEA-WATER CORROSION BEHAVIOR OF ALUMINUM-BRONZE ALLOYS
R. E. Maersch Jun. 1966 20 p ref
(MEL-196/66; AD-635288) CFSTI: HC $6.00/MF $0.50

Some compositions of aluminum–bronze alloys suffer an insidious type of selective-phase attack in seawater. One proposed method to improve the corrosion behavior of these materials was the addition of minor alloying elements to promote the formation of microstructural consitutents that are electrochemically compatible. Three experimental alloys, containing small amounts of tin, nickel and arsenic, respectively, were analyzed after sea-water exposure. None of the minor alloying additions imparted significant improvement in corrosion behavior of the base alloy. Author (TAB)

N66-34881# Naval Civil Engineering Lab., Port Hueneme, Calif.
POTENTIAL APPLICATIONS OF RADIOISOTOPES IN THE NAVY Final Report, Feb. 1963-Jun. 1965
L. B. Gardner, A. E. Hanna, and H. E. Stanton May 1966 27 p refs
(R-445; AD-633785) CFSTI: HC $2.00/MF $0.50

The Naval Civil Engineering Laboratory has conducted a study of the potential applications of isotopic devices and techniques within the Naval Shore Establishment. Radiation characteristics, general applications of isotopic devices, and specific problem areas are discussed. Recommendations are included for the use of surface density and moisture gages in the inspection of compacted earth, and for additional work in the determination of the thickness of in-place steel sheet piling and the thickness and density of concrete.
Author (TAB)

N66-34925# Naval Boiler and Turbine Lab., Philadelphia, Pa.
CORROSION BEHAVIOR OF 16% CHROMIUM-1% NICKEL DESUPERHEATER ALLOY WHEN EXPOSED TO CHEMICAL DESCALANTS Final Evaluation Report
H. Meyer and J. A. Mc Kelvey 17 Jun. 1966 25 p
(AD-635368) CFSTI: HC $1.00/MF $0.50

An investigation was made to develop a suitable descalant formulation to permit chemical cleaning of 16% chromium–1% nickel (16-1 Croloy) desuperheaters, without deleterious effects. Based on bench studies, these elements can be descaled safely with the boiler scale removing compound (sulfamic acid, citric acid, diethylthiourea) containing an inhibitor supplement. In addition, this formulation may be used to descale boilers with the 16-1 Croloy desuperheaters intact. A full scale boiler cleaning operation should be initiated to confirm the successful bench scale findings.
Author (TAB)

N66-34941# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
CALCULATION OF THERMAL CONDITIONS OF ROLLER BEARINGS OF GAS-TURBINE ENGINES
V. M. Demidovich 17 Jan. 1966 18 p refs Transl. into ENGLISH from Tr. Kazansk. Aviats. Inst. (Kazan), no. 66, 1961 p 49-62
(FTD-MT-65-32; TT-66-61690; AD-635280) CFSTI: HC $4.00/MF $0.50

The method of thermal calculation of GTE roller bearings permits solving of the problem, important for practice, of calculating the necessary magnitude of circulation of oil through housings of bearings, which ensures operation of the latter at assigned operating temperature, which increases reliability and long service life of their operation. Author (TAB)

N66-35008# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Research Dept.
THE USE OF A SIMPLIFIED NEUTRON ACTIVATION TECHNIQUE FOR ANALYZING METALLIC WEAR FROM AIRCRAFT HYDRAULIC SYSTEMS
M. D. D'Agostino and F. J. Kuehne Jun. 1966 47 p refs Presented at the First Symp. on Radioisotope Appl. in Aerospace, Dayton, Ohio, 15-17 Feb. 1966
(Contract NOw-63-0708-c)
(RE-254J; AD-483535)

A simplified, inexpensive means of using neutron activation analysis to detect metallic deterioration products filtered out of hydraulic systems has been developed. The simplifica-

tion of established activation analysis techniques was made possible by reducing the analysis of complex gamma ray spectra (resulting from the activation of a mixture of several elements) to a simple procedure, and by the availability of small, inexpensive neutron generators (producing 14.5 MeV neutrons) and multi-channel analyzers. Authro (TAB)

N66-35016*# Marlin-Rockwell Corp., Jamestown, N. Y. MRC Research.

SPIN AXIS BEARINGS Summary Report

Daniel J. Howles and Harold E. Munson 27 Jun. 1966 77 p (Contract NAS8-5441)

(NASA-CR-77365) CFSTI: HC $3.00/MF $0.75 CSCL 13I

Twelve experimental lots of spin axis bearings, involving nine different raceway finishes, were manufactured. After dynamic testing of the bearings in gyro assemblies, bearing failures were analyzed. From the combination of knowledge of manufacturing techniques, documentation of prerun and postrun bearing measurements, life test data, and failed bearing analyses, several conclusions were reached: (1) three methods of finishing spin axis bearing raceways produce superior performance and life under marginal lubrication conditions, (2) bearing life cannot be correlated with high luster under magnified visual observation nor with geometry of the race in the low microinch range, (3) measurement data from instruments were most useful for process and contamination control and historical records, rather than as the final criteria for predicting bearing life, and (4) bearings with unidirectional, circumferential surface finish lay performed better than those with irregular or cross-the-race lay. Additional work was done on controlling the oil bleed rate from the impregnated retainers. The results demonstrated the promise of this approach toward improving bearing life, but further development is necessary before it can be incorporated into operational gyros. Author

N66-35207*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FRICTION CHARACTERISTICS OF SINGLE CRYSTAL AND POLYCRYSTALLINE ALUMINUM OXIDE IN CONTACT IN VACUUM

Donald H. Buckley Washington, NASA, Sep. 1966 15 p refs (NASA-TN-D-3599) CFSTI: HC $1.00/MF $0.50 CSCL 11B

An investigation was conducted in vacuum to gain a better understanding of the friction and adhesion concepts of the ceramic material aluminum oxide in its single-crystal (sapphire) and polycrystalline forms in sliding contact with aluminum oxide of the same crystallinity. Experiments were conducted in a vacuum to 10^{-10} millimeter of mercury with surfaces which were outgassed. The specimens were a hemispherical or spherical surface sliding on a rotating flat surface. The materials were studied at rotating speeds of 0.013 centimeter per second, loads to 1500 grams, and ambient temperatures to 575° C. The results of the investigation have shown that the friction characteristics for sapphire sliding on sapphire are highly anistropic and are determined by plastic deformation of the sapphire. With the pollycrystalline material, friction coefficients obtained were intermediate between the values obtained for the prismatically and basally oriented single-crystal material. Author

N66-35260# United Nuclear Corp., Elmsford, N. Y. Research and Engineering Center.

STUDY OF URANIUM–PLUTONIUM MONOXIDES Final Summary Report

J. Andersen, K. Taylor, R. L. Forbes, and N. Fuhrman (Carborundum Co.) 31 Jan. 1966 81 p refs Prepared Jointly with Carborundum Co.

(Contract AT(30-1)-3305)

(UNC-5144; EURAEC-1566) CFSTI: HC $3.00/MF $0.75

Uranium–plutonium monoxide compositions of the types $(U_{0.9}Pu_{0.1})(O_xC_{1-x})$ and $(U_{0.9}Pu_{0.1})(O_xC_yN_z)$ were synthesized by carbon and uranium reduction methods starting with UO_2–PuO_2 mixtures. Pure (UPu)O or PuO compounds, as well as nitrogen-stabilized uranium–plutonium monoxides $(U_{p.o}Pu_{0.1})(O_xN_{1-x})$, could not be synthesized. The maximum oxygen content found in essentially single-phase $(U_{0.9}Pu_{0.1})(O_xC_{1-x})$ was approximately x = 0.4. Higher monoxide oxygen contents, approaching x = 0.6, were found in materials containing 15% or more of a dioxide phase. Nearly single-phase $(U_{0.9}Pu_{0.1})(O_xC_yN_z)$ compositions were obtained when the intended oxygen content was no greater than x = 0.3 and the O/C atom ratio was no more than 1. $Pu(O_xC_{1-x})$ compositions were prepared having estimated oxygen contents as high as x = 0.6. Corrosion testing to evaluate these fuels for water-cooled thermal reactor application demonstrated that: in boiling water, the $(U_{0.9}Pu_{0.1})(O_xC_{1-x})$ materials hydrolyzed while $(U_{0.9}Pu_{0.1})(O_xC_yN_z)$ compositions with carbon contents less than y = 0.4 were essentially unaffected; and in 550° F water, all monoxide-type materials disintegrated. Typical monoxide-type compositions appeared to have higher room temperature thermal conductivities than those of $(UPu)O_2$ and UO_2 Author (NSA)

N66-35646*# Atomics International, Canoga Park, Calif.

SOLUBILITY OF REFRACTORY METALS AND ALLOYS IN ALKALI METALS First Quarterly Report, Mar. 3–May 28, 1966

R. L. Mc Kisson and R. L. Eichelberger 18 Jul. 1966 25 p refs

(Contract NAS3-8507)

(NASA-CR-54993; AI-66-115) CFSTI: HC $1.00/MF $0.50 CSCL 11F

Purpose of the study was to investigate solubilities of refractory metals and alloys in liquid alkali metals and to develop data for formulation of corrosion resistant alloys required for systems employing alkali metal coolants. The solution behavior of gettered alloys in highly purified potassium was observed in order to determine the effect of oxygen on solubility. The alloys, the solute materials, and the high temperature furnace required for further verifications are described. Test welds of T-111 to Cb-1Zr and of Cb-1Zr to Mo-1/2Ti were successfully made. The experimental system, consisting of five sequence-connected stainless steel vacuum chambers, each with its own pumping system and separated by vacuum gate valves, is briefly described. K.W.

N66-35694# United Kingdom Atomic Energy Authority, Springfields (England).

THE RELATION OF PROOF TESTING TO LONG-TERM CORROSION BEHAVIOR OF ZIRCONIUM ALLOYS

P. L. Allen, D. A. Moore, and F. W. Trowse 12 May 1966 43 p refs

(TRG-1134(S)) CFSTI: HC $2.00/MF $0.50

The results of proof tests performed in various ways are reported, and correlated with subsequent long-term corrosion behavior and with the heat treatment and microstructure of the alloys. The operational procedure over the start-up period of the proof test, during which the first 2000 Å thick layer of oxide forms, influences oxidation and hydrogen uptake both during this proof test and throughout the subsequent pretransition period of corrosion. With Zircaloy-2 having satisfactory corrosion behavior, hydrogen uptake over this pretransition period can be varied by a ratio of 3:1 by appropriate choice of start-up conditions for a proof test in steam at 400°C, 1500 lb/in^{2}g. Unsatisfactory distribution of intermetallic precipitates in Zircaloy-2 is detected by proof testing

at 100 lb/in^{2}g., but not at 1500 lb/in^{2}g. A difference in behavior for a given material, depending on whether it is tested in the form of fuel tubing or of flat plates, is reported. Author

N66-35700# European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center.
STATISTICAL TECHNIQUES AND ANALYSIS IN CORROSION MEASUREMENTS OF Zr ALLOYS IN TERPHENYLS
G. C. Impariso and M. Cocchi Jun. 1966 22 p refs
(EUR-2997.e) CFSTI: HC $1.00/MF $0.50

The scope of this paper is to describe the theoretical criteria and the experimental procedures adopted to investigate the agents that cause corrosion of Zr alloys in terphenyls; this work represents a first approach to this, indeed complex, problem. Author

N66-35879# Compagnie des Ateliers et Forges de la Loire, Paris (France). Dept. des Recherches.
[MECHANICAL PROPERTIES OF STEELS] Quarterly Report No. 5, Oct.–Dec. 1965
[1966] 64 p
(Contract EURATOM-033-64-9TEE-F(RD))
(EUR-2807; EURAEC-1578) CFSTI: HC $3.00/MF $0.75

Results of the continued stress corrosion testing of austenitic and austeno-ferritic stainless steels in various chloride solutions are reported. Observations made to date on the effects of the pH of the solution, silicon and molybdenum content of the steels, and the austeno-ferritic structure on the stress corrosion of steels are summarized. NSA

N66-35935*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INFLUENCE OF A VACCUM ENVIRONMENT ON FRICTION AND LUBRICATION STUDIES
Donald H. Buckley *In its* High-Vacuum Technol., Testing, and Meas. Meeting Aug. 1966 p 201–211 refs (See N66-35906 21-11) CFSTI: HC $6.00/MF $1.50

The importance of a clean vacuum system on the friction characteristics of metals in sliding contact is discussed, and friction and mass spectrometer data are presented. Furthermore, the influence of vacuum system total and oxygen partial pressures is shown to affect markedly the friction behavior of metals in sliding contact. The relation of metal oxide stability to oxygen partial pressures and friction characteristics of metals is also discussed. The poor heat dissipation for materials in a vacuum is shown to affect the temperatures of sliding contact metals in friction studies. This poor heat dissipation is also related to the mechanisms of degradation of materials such as polytetrafluoroethylene in friction experiments. Author

N66-36121*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
FRICTION CHARACTERISTICS OF SINGLE-CRYSTAL AND POLYCRYSTALLINE ALUMINUM OXIDE IN CONTACT WITH VARIOUS METALS IN VACUUM
Donald H. Buckley Washington, NASA, Sep. 1966 18 p refs
(NASA-TN-D-3593) CFSTI: HC $1.00/MF $0.50 CSCL 11B

An investigation was conducted in vacuum to gain a better understanding of the friction and adhesion concepts of the ceramic material aluminum oxide in its single-crystal and polycrystalline form in sliding contact with various metals. Experiments were conducted in a vacuum to 10^{-10} torr with surfaces that were outgassed. The specimens were a hemispherical or a spherical surface sliding on a rotating flat. The materials were studied at rotating speeds of 0.013 centimeter per second, loads to 1500 grams, and ambient temperatures to 575° C. The results of the investigation show that, with metals sliding on sapphire, stresses result in fracture within the sapphire. These fracture stresses determine the measured friction. When metals were slid on polycrystalline aluminum oxide, adhesion of the metal to the aluminum oxide resulted in shear in the metals. Coefficients of friction for most hexagonal metals sliding on aluminum oxide were lower than for cubic metals sliding on aluminum oxide. Adhesion of metal to aluminum oxide occurs in air as well as with clean surfaces in vacuum. Author

N66-36128*# Hydronautics, Inc., Laurel, Md.
CAVITATION DAMAGE IN LIQUID METALS Final Report
A. Thiruvengadam and H. S. Preiser 29 Nov. 1965 79 p refs
(Contract NAS3-4172)
(NASA-CR-72035; TR-467) CFSTI: HC $3.00/MF $0.75 CSCL 11F

This report summarizes the results of investigations on the cavitation damage resistance, the high frequency fatigue and the stress corrosion behavior of five metals in liquid sodium up to 1500° F. The test duration is an important parameter in evaluating the relative cavitation damage resistance. Stellite 6B exhibits the greatest resistance as compared with Cb-132M, T-222, TZM and 316 stainless steel. The rate of damage decreases with increasing temperature. High frequency fatigue tests at ~35 ppm and at ~100 ppm oxide contamination in liquid sodium up to 1500°F show that the oxide content does not change the fatigue behavior of TZM and 316 stainless steel. The fatigue of 316 stainless steel in 1500°F sodium at 14,000 cps is comparable with the results obtained at 1500°F vacuum (3×10^{-5} torr) at 4–5 cps. No stress corrosion cracking was observed on TZM and on 316 stainless steel over a 60 hour test at two oxide levels (≈35 ppm and ≈100 ppm) in liquid sodium at 1000° F and 1500° F up to 100% yield. Author

N66-36185# Titanium Metals Corp. of America, West Caldwell, N. J. Techical Service Dept.
Ti–6Al–2Sn–4Zr–2Mo—A NEW HIGH TEMPERATURE ALLOY WITH AN OUTSTANDING COMBINATION OF PROPERTIES FOR SERVICE TO 1050°F
31 Jan. 1966 26 p

A super-alpha alloy optimized to provide an excellent combination of creep strength, ultimate tensile strength, toughness, and stability to 1050°F was produced. The Ti–6Al–2Sn–4Zr–2Mo alloy has a density of 0.164 lbs/in^3. The alloy development and forging programs are described. Test results are discussed and data is presented in tabular and graph form on tensile properties, pre-crack Charpy impact tests, mechanical properties at temperatures in the 100° – 1100°F range, creep stability, and salt stress corrosion. N.E.N.

N66-36208# Army Foreign Science and Technology Center, Washington, D. C.
PATHS OF DEVELOPMENT OF STATIONARY GAS TURBINE ENGINES IN USSR. USE OF PETROLEUM FUEL AND DISSOLVED ADDITIVES FOR LOWERING VANADIUM CORROSION IN GAS TURBINE ENGINES
G. I. Shuvalov, G. G. Ol'khovskiy, R. A. Lipshteyn Jun. 1966 22 p refs Transl. into ENGLISH from Teploenerg. (Moscow), no. 9, 1964 p 2–6, 19–21
(FSTC-HT-23-122-66; TT-66-61589; AD-634815) CFSTI: HC

$1.00/MF $0.50

The first article surveys the results of experimental development of Soviet gas turbine engines and ways of using them in power engineering. Detailed tables are given showing characteristics of various engines. The second article considers the question of choice of additives to sulfurous petroleum fuel permitting the avoidance of appreciable vanadium corrosion during the operation of the gas turbine engines. Author (TAB)

N66-36266# Los Alamos Scientific Lab., N. Mex.
ADVANCED REACTOR TECHNOLOGY (ART) Quarterly Status Report, Period Ending 31 Jan. 1966
8 Mar. 1966 73 p refs
(Contract W-7405-ENG-36)
(LA-3482-MS) CFSTI: HC $3.00/MF $0.75

Further developments in construction of the Fast Reactor Core Test Facility (FRCTF) are reported. Preliminary calculations for the Molten Plutonium Burnup Experiment (MPBE) are given. The corrosive effects of molten Pu alloys on Ta and Ta–W fuel capsules are presented. The results are also presented for carburized fuel capsules. Sodium technology and other supported research to be used in conjunction with the MPRE are included. NSA

N66-36692*# General Electric Co., Philadelphia, Pa.
FLIGHT-PROVEN MECHANISMS ON THE NIMBUS WEATHER SATELLITE
S. Charp and S. Drabek *In* JPL 1st Aerospace Mech. Symp. [1966] 26 p (See N66-36691 22-31) CFSTI: HC $7.00/MF $2.00

Designs and performance of the mechanical devices and subsystems are discussed. They are divided into groups of sealed or unsealed components, with continuous, single, or repeated operations. Among the conclusions are: (1) Space environment is not severely limiting on the design. (2) Hard vacuum conditions influenced the choice of materials for components and lubricants, primarily as a function of their vaporization and outgassing. (3) The Versilube G-300 silicone grease proved most satisfactory for use with small, unsealed, motorgear drives and for large, slow speed bearings. (4) High energy proton and electron bombardment from the van Allen belt and from solar flares did not prevent the use of any mechanism. (5) Solar ultraviolet and low energy proton and electron bombardment did not influence design except with respect to thermal coatings. N.E.N.

N66-36709*# Santa Clara Univ., Calif.
CONICAL PIVOT BEARINGS FOR SPACE APPLICATIONS
George G. Herzl *In* JPL 1st Aerospace Mech. Symp. [1966] 21 p refs (See N66-36691 22-31) CFSTI: HC $7.00/MF $2.00

Conical pivot bearing characteristics and performance are analyzed, and criteria for minimal torque design are presented. Contact loads are considered for the pivot axis position for which friction torque is maximal (horizontal) and minimal (vertical), and the friction torque is calculated. Contact pressure and area are discussed and a method of determining minimum allowable pivot tip radius is given. Both contact in spherical and conical region are included. N.E.N.

N66-36770*# Hughes Research Labs., Malibu, Calif.
MAGNETIC BEARING AND DRIVE
In its Res. on Gravitational Mass Sensors [1966] 12 p (See N66-36766 22-14) CFSTI: HC $7.36/MF $2.25

A magnetic bearing and drive system capable of supporting a composite rotor having a weight in excess of 5 lb. is described. It is reported that the drive system is capable of accelerating the rotor up to angular speeds in excess of 1000 rps when the rotating components are enclosed in a vacuum tight chamber maintained at a pressure not exceeding 50μ Hg. The major components of the support system including the magnetic support solenoid and drive motor assembly, magnetic support circuit, current control circuit, rotor drive circuit, and speed pickup system are discussed. Mechanical relationships between the magnetic support solenoid and drive motor assembly components are shown, and a block diagram is given of the magnetic support circuit along with the various circuit interconnections required for normal operation. A.G.O.

N66-36957# General Electric Co., Schenectady, N. Y. Knolls Atomic Power Lab.
FRICTION FACTORS FOR USE IN ANALYSIS OF JOURNAL BEARINGS WITH VORTEX-TURBULENT FLOW
R. J. Fritz 24 Feb. 1966 19 p refs
(Contract W-31-109-ENG-52)
(KAPL-M-6546) CFSTI: HC $1.00/MF $0.50

Friction factors were estimated for Couette turbulence occurring in long sleeve bearings. The estimates were based on pipe flow correlations and are shown to agree very well with Robertson's data using the roughness factor $\epsilon/D=0.0004$. It is predicted that a practical bearing will have significantly greater relative roughness. Friction factors are proposed for combined Reynold's (turbulent) and Taylor's (vortex) correlations assuming a roughness $\epsilon/D=0.004$ which is considered reasonable for a bearing surface of ASA roughness 10 and a radial bearing clearance of 5 mils. A proposal is made to estimate the friction factor for axial flow combined with rotational flow. These proposals are intended to apply to moderate bearing eccentricities, the range of which must be established by test. Author (NSA)

N66-36958# General Electric Co., Schenectady, N. Y. Knolls Atomic Power Lab.
SOME CONSIDERATIONS OF ROTOR DYNAMICS INCLUDING VIRTUAL MASS AND STABILITY EFFECTS
R. J. Fritz 24 Feb. 1966 23 p refs
(KAPL-M-M-6543) CFSTI: HC $1.00/MF $0.50

Bearing equations are derived for small deflections of a noncavitating, long-sleeve bearing, based on continuity and a turbulent form of the Navier–Stokes equation and including inertial terms. This bearing was shown to be inherently unstable. A virtual mass is calculated which agrees with the results of previous work for the case of no rotation and agrees with bearing theory for the case of half-frequency whirl. A dynamic system was considered which is intended to represent a tilted-pad bearing with displacement cross-coupling. The criterion for stability for this system was shown to depend on the degree of cross-coupling. Author (NSA)

N66-36982# Ohio State Univ. Research Foundation, Columbus.
A STUDY OF THE MECHANISM OF STRESS CORROSION CRACKING IN THE IRON-NICKEL-CHROMIUM ALLOY SYSTEM Quarterly Report, Dec. 17, 1965–Mar. 16, 1966
R. W. Staehle 28 Apr. 1966 37 p
(Contract AT(11-1)-1319)
(COO-1319-39) CFSTI: HC $2.00/MF $0.50

Work on installing a source of high-purity water was completed. A preliminary study of the effect of specimen surface preparation on time to breaking suggested that the explanation for the wide range of the data may lie in the nature of the passive film. The effect of boiling $MgCl_2$ on time to breaking of

various alloy compositions is being studied for subsequent comparison with results from circulating autoclave studies. Information from boiling $MgCl_2$ studies showed cracking in commercial alloys at nickel contents as high as 55%. Thin foils of iron were exposed to boiling $MgCl_2$ with the result that stressed foils exhibited dissolution patterns that suggest preferential dissolution in regions through which mobile dislocations passed. This finding was similar to the results for pure nickel and various ternary alloys. Author (NSA)

N66-37070# Pacific Missile Range, Point Mugu, Calif.
USE OF TEFLON TO REDUCE CORROSIVE EFFECTS ON SHIPBOARD ANTENNAS
L. C. Read 14 Mar. 1966 36 p
(PMR-TM-66-1; AD-635858) CFSTI: HC $2.00/MF $0.50

A coating material containing Teflon was used to repaint shipboard antennas undergoing maintenance or rehabilitation. The purpose of the project was to eliminate or reduce the corrosive effects of stack effluent, a major cause of the corrosion which results in antenna deterioration and failure. The corrosion problems connected with shipboard antenna maintenance are analyzed and illustrated. Current antenna procedures are described and their costs analyzed in terms of repeated antenna rehabilitation and reliability. The results of the project using the coating material containing Teflon are described and illustrated together with an analysis of relative cost and reliability. Author (TAB)

N66-37251# Naval Applied Science Lab., Brooklyn, N. Y.
INVESTIGATION OF PLATINGS OF ELECTRICAL CONTACTS
8 Jul. 1966 29 p refs
(TM-1; AD-636193) CFSTI: HC $2.00/MF $0.50

MIL-C-26636 size 16 and 20 pin and socket contacts were electroplated with gold over silver, gold over nickel, gold over copper, rhodium over nickel, and rhodium over silver. Plated contacts were wired and assembled in a modified louvered stevenson screen and installed at the NASL marine environmental site at Ft. Tilden, N. Y. mounted on a supporting structure facing the ocean without obstruction, approximately 500 feet from the shore line and 40 feet above M.L.W. Analysis of tarnish films deposited on exposed copper plates during the initial two months at the Ft. Tilden test site indicates a suitable marine environment free of sulphide contamination. Contact resistance measurements on contacts mated 100 times as compared to contacts mated once, prior to exposure, show no significant difference except for a 30% increase for those plated with rhodium over nickel. The contact resistance measurements made during the first two months of exposure indicate a slight increase in the average contact resistance of all contacts. Author (TAB)

N66-37340# General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.
SPECIFIC ZIRCONIUM ALLOY DESIGN PROGRAM Quarterly Progress Report No. 9, Apr.–Jun. 1965
H. H. Klepfer, C. J. Baroch, R. E. Blood, J. L. Jaech, and E. A. Pickett Jul. 1965 55 p refs
(Contract AT(04-3)-189)
(GEAP-4840; EURAEC-1460) CFSTI: HC $3.00/MF $0.75

The Specific Zirconium Alloy Design Program was reinstated in November 1964 for the evaluation of a Zr+2.0 at. % Cr+0.16 at. % Fe alloy as nuclear fuel cladding. Tubing and bar stock of the alloy was obtained by fullscale vendor fabrication. Alloy-clad fuel rods were fabricated for irradiation in Consumer's Big Rock Reactor to a target exposure of 15,000 MWD/T. Technologically, there were no fabrication difficulties with the alloy. The fuel irradiation was delayed, however, by variable corrosion performance by this first vendor batch of alloy tubing and bar stock. Further tests on laboratory melts run side-by-side with the vendor samples confirmed the potential of the composition for excellent corrosion performance. The difference in performance between material from large, slow-cooling vendor ingots and small, fast-cooling laboratory melts was shown to be related to the size and uniformity of distribution of the intermetallic precipitates in the alloy. Material re-melted from the vendor forging and processed in the laboratory gave excellent performance; purposely slow-cooled laboratory samples gave poor performance in the same test. Experiments to determine the proper fabrication schedule for control of microstructure in full-scale processing are to be made. Another experiment is in progress to establish the effect of nitrogen content in the range of 20 to 500 ppM on the corrosion rate of Zr+2.0 at. % Cr+0.16 at. % Fe in high-pressure, refreshed steam at 300, 400, and 500°C. Author (NSA)

N66-37387# Naval Radiological Defense Lab., San Francisco, Calif.
ELECTROCHEMICAL CORROSION STUDIES OF SNAP CONTAINER MATERIALS
Dona A. Kubose and Herman I. Cordova 7 Jun. 1966 28 p refs
(USNRDL-TR-1036; AD-635682) CFSTI: HC $2.00/MF $0.50

Corrosion rates of Haynes 25, Hastelloy C and Hastelloy N in natural seawater were determined by galvanostatic polarization techniques. Values of approximately 10^{-2} mils per year were obtained for each of the alloys. No significant effect of aeration and solution stirring on the corrosion rates were observed. Author (TAB)

N66-37392# Marine Engineering Lab., Annapolis, Md.
GALVANIC CORROSION BEHAVIOR OF WEAR-RESISTANT MATERIALS FOR MECHANICAL SHAFT SEALS
D. C. Vreeland Jul. 1966 15 p ref
(MEL-242/66; AD-635592) CFSTI: HC $2.00/MF $0.50

Shaft seals currently used on submarines employ mating wear surfaces which are supported by Monel carrier rings. Galvanic corrosion effects between various candidate mating materials and Monel have been investigated by the exposure of couples in seawater. The 14 materials exposed included seven cobalt-chromium alloys, six sintered carbide materials, and one copper-lead-tin alloy. The results indicate that galvanic coupling to Monel had no adverse effect on the corrosion behavior of five of the cobalt-chromium alloys, and one of the sintered carbide materials. Author (TAB)

N66-37460# Carnegie Inst. of Tech., Pittsburgh, Pa.
SOME EFFECTS OF NITROGEN ON THE RESISTANCE TO STRESS CORROSION CRACKING OF TYPE 304 STAINLESS STEEL WIRES
Walter A. Mannheimer and Harold W. Paxton 15 Jun. 1966 16 p refs
(Contract Nonr-760(14))
(AD-635630) CFSTI: HC $1.00/MF $0.50

In recent work on stress corrosion cracking, the role of alloying elements which may effect dislocation distribution and cracking has been discussed. Nitrogen has been introduced into austenitic stainless steels in the solid state from NH_3/H_2 mixtures at temperatures in the range 600–750°C. The resistance to cracking is markedly improved. The reasons for this improvement are under investigation. Author (TAB)

N66-37936# United Kingdom Atomic Energy Authority, Risley (England). Reactor Engineering Lab.
FRICTION AND WEAR BEHAVIOR OF SLIDING BEARING MATERIALS IN SODIUM ENVIRONMENTS AT TEMPERATURES UP TO 600° C
W. H. Roberts 1966 44 p refs Submitted for Publication
(TRG-1269(R)) CFSTI: HC $2.00/MF $0.50

Friction and wear data, obtained with a crossed-cylinders apparatus, are presented for a selection of molybdenum-tungsten-chromium alloys, over the temperature range 200–600°C, for two sodium environments: the molten metal, containing approximately 5 ppm of oxygen impurity; and pure argon containing sodium vapor. An indication is given of the effect on friction and wear behavior of increasing the oxygen content in liquid sodium, from about 5 to 80 ppm. Chemisorbed double-oxide films, formed by reaction of the molybdenum, tungsten, chromium, and iron constituents of the alloys with the sodium environment, play a significant role in providing boundary lubrication in high-temperature sodium. The effectiveness of the lubrication provided by such films is a function of the specific nature of the sodium environment, and of temperature, as well as time at temperature. Another source of boundary lubrication considered to have been operative, more especially with cobalt- and nickel-base spray-fused hard-facing alloys, were compounds of constituents of these alloys which had intrinsic anti-friction and anti-wear properties and whose efficacy does not primarily depend on reaction with sodium. Author

N66-38062# Verfinstituut Tno, Delft (Netherlands).
REAPPLICATION OF AN OLD LAYER OF FUNGUS-PREVENTIVE PAINT [OVERSCHILDERBAARHEID VAN EEN VEROUDERDE AANGROEIWERENDE VERFLAAG]
A. M. van Londen 27 Jun. 1966 9 p In DUTCH
(V-66-250; TDCK-45769) CFSTI: HC $1.00/MF $0.50

Fungus-preventive paints were aged by exposing the test panels to flowing seawater at a temperature of 30°C for five weeks. The test panels were dried and cleaned, and three different types of paint were applied over the original coating to determine their effectiveness. The panels were then exposed to seawater flowing at a speed of 40 knots, again at 30°C temperature, for 16 days. Comparative data are tabulated for each paint tested. Transl. by J.O.

N66-38065# Metaalinstituut Tno, Delft (Netherlands).
RESEARCH ON A TORN END CAP OF A SIKORSKY HELICOPTER [ONDERZOEK VAN EEN GESCHEURDE "END CAP" VAN EEN SIKORSKY HELICOPTER]
P. Breedveld 7 Jun. 1966 14 p In DUTCH
(TDCK-45713; M66-479) CFSTI: HC $1.00/MF $0.50

Visual examinations and spectrographic techniques were used to examine a tear found in the crosspiece of an aluminum end cap from a main rotor servo unit assembly. The findings showed that the cap contained an insert attached with a lock ring, which was forced into a slightly smaller opening. Due to this attachment method, the aluminum was forced up and out by the gear formations, and tensile stress developed. It was concluded that the Al–Zn–Mg–Cu aluminum alloy used is fairly sensitive to stress corrosion, especially when the tensile stress is perpendicular to the side wall; as the helicopter was used in a somewhat rough environment (over the ocean), stress corrosion could begin under comparatively low stress. Transl. by J.O.

N66-38146*# General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.
POTASSIUM CORROSION TEST LOOP DEVELOPMENT
Quarterly Progress Report No. 10, 15 Oct. 1965–15 Jan. 1966 E. E. Hoffman ed. 9 Jun. 1966 41 p refs
(Contract NAS3-2547)
(NASA-CR-54990) CFSTI: HC $2.00/MF $0.50 CSCL 14B

Progress is reported in the development and endurance testing (5000 hours) of a prototype corrosion test loop for the evaluation of refractory alloys in boiling and condensing potassium environments which simulate projected space electric power systems. The prototype test consists of a two-loop Cb-1Zr facility; sodium is heated by direct resistance in the primary loop and used in a heat exchanger to boil potassium in the secondary corrosion test loop. It is reported that a total of 3,809 hours of the 5,000 hour test was completed when a pressure rise in the test chamber necessitated a shutdown. The pressure rise resulted from stress-corrosion cracking of one of the stainless steel water cooling channels of the test chamber wall, and emphasis is placed on methods and procedures used in repairing this failure. C.T.C.

N66-38254# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
THE EFFECT OF LUBRICANTS ON THE COLD ROLLING OF THIN STRIPS AND BELTS OF VT-14, VT-15, AND VT-16 TITANIUM ALLOYS
I. M. Pavlov, S. F. Burkhanov, E. R. Shor, E. Ye. Osinov, and A. M. Chinenov 21 Mar. 1966 14 p refs Transl. into ENGLISH from Izv. Vysshikh Uchebn. Zavedenii, Chern. Met. (Moscow), no. 9, 1964 p 88–94
(FTD-TT-65-1955; TT-66-61949; AD-636663) CFSTI: HC $1.00/MF $0.50

The most effective lubricant (of those investigated) during rolling of strips of VT-14, VT-15, and VT-16 down to a thickness of 0.8 mm is the synthetic lubricant LZ-203. Destruction (full or partial) of the metal is observed when strips thinner than 0.8 mm are rolled with lubricant LZ-203. The edges of the strips of alloy VT-14 are especially strongly destroyed. Caster oil is recommended as the lubricant for rolling very thin strips and foils of alloys VT-14, VT-15 and VT-16. Lubricants LZ-142 and LZ-142a, which are complex esters, turned out to have low effectiveness (during rolling of titanium alloy into lubricant LZ-142a) did not have a noticeable improving effect on this technical lubricant. In separate tests the oxide film formed on the surface of the investigated titanium alloys was observed to have lubricating properties. The possibility of producing a foil from the alloys VT-14, VT-15, and VT-16 was established. In this the strip thickness of 0.13 mm, which was obtained on a duo 150 stand with the application of caster oil, is not the limiting possible thickness. The application of intermediate annealing and more advanced rolling equipment will allow us to produce a foil thinner than 0.1 mm. Author (TAB)

N66-38383# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
METHODS OF COMPLEX EVALUATION OF OPTICAL LUBRICANTS
R. A. Levento 23 May 1966 15 p refs Transl. into ENGLISH from Tr. Mosk. Inst. Neftekhim. i Gaz. Prom. (Moscow), no. 44, 1963 p 251–257
(FTD-TT-65-1506; TT-66-61948; AD-636662) CFSTI: HC $1.00/MF $0.50

The recommended methods of complex laboratory evaluation of the lubricants for optico-mechanical instruments enable one to make a basic selection. The most important parameter which determines the specific properties of lubricants for optico-mechanical instruments is their tendency to the formation of oily deposits on optical parts. There are no satisfactory methods for laboratory evaluation of this index. Author (TAB)

N66-38644# Societe d'Etudes, de Recherches et d'Applications pour l'Industrie, Brussels (Belgium).
STUDIES OF STEEL CORROSION IN HIGH-TEMPERATURE WATER AND STEAM Quarterly Report No. 14, 1 Jan.-31 Mar. 1966
29 Apr. 1966 137 p refs Transl. into ENGLISH from FRENCH (Contract EURATOM-087-66-1 TEEB (RD))
(EURAEC-1625; EUR-2838) CFSTI: HC $4.00/MF $1.00

Surface work-hardening effects on the oxidation of Cr and Cr-Ni steels in steam above 400°C were studied to define their recrystallization conditions. It was shown that mass work-hardening, produced by drawing of up to 15%, does not alter the corrosion behavior of 304 steel in steam at 500°C. Results of long-duration tests at 500°C by the hydrogen diffusion method confirm the need for a certain depth of work-hardening to guarantee good long-term behavior. The growth mechanism of the oxide layers on the nonsurface-work-hardened states of the same steels treated in superheated steam was examined to clarify the initial growth conditions of these layers. The epitaxial character of the outer magnetite layer still required explanation. An examination of oxide skins corresponding to residences of about 2 hours in steam at 500 and 450°C revealed the formation of a finely crystallized continuous skin (the size of the crystals was about 500 Å), on which the magnetite crystals of the outer layer seem to form. Corrosion of stainless steels in pressurized water was further investigated to clarify the mechanisms responsible for the maximum corrosion point at 200 to 250°C. It was shown that the oxidation mechanism takes the form of reciprocal migration. The decomposition of ferrous hydroxide formed by diffusion of iron ions, into insoluble magnetite, leads to the formation of coarse magnetite crystals which grow epitaxially. Magnetite crystallization from the solution is liable to cause mass transfers from one grade of steel to another, and from the coldest to the hottest parts of the system. The maximum observed as a function of the experimental temperature is due qualitatively to the combination of the two kinetics of ferrous hydroxide production, on the one hand, and its decomposition into magnetite on the other. Surface treatment effects on the corrosion of Zircaloy 2 in pressurized water and superheated steam was examined. Surface treatment does not appear to affect the oxidation resistance of this alloy. On the other hand, a harmful influence of surface work-hardening is observed on the hydridization rate. Electrolytic polishing is generally favorable as regards both the hydridization rate and the distribution of the hydrides. NSA

N66-38681# Ohio State Univ. Research Foundation, Columbus.
CIRCULATING AUTOCLAVE SYSTEM FOR STRESS-CORROSION CRACKING STUDIES
R. W. Staehle May 1966 37 p refs Presented at 69th Ann. Meeting of the Am. Soc. For Testing and Mater., Atlantic City (Contract AT(11-1)-1319)
(COO-1319-40; CONF-660607-2) CFST : HC $2.00/MF $0.50

A circulating autoclave system was constructed and operated in which time to breaking can be determined exactly at temperatures to 700°F, pressures to 5000 psi, a wide range of stresses, various dissolved gas and ionic specie concentrations, and for a large number of specimens exposed simultaneously. Preliminary experiments studied commercial and specially melted iron–nickel–chromium alloys. Results confirmed already established trends of environment and alloy influences at 500°F. Author (NSA)

N66-38725*# General Electric Co., Cincinnati, Ohio. Missile and Space Div.
POTASSIUM CORROSION TEST LOOP DEVELOPMENT; PURIFICATION, ANALYSIS AND HANDLING OF SODIUM AND POTASSIUM Topical Report No. 4
L. E. Dotson and R. B. Hand 13 Jun. 1966 190 p refs (Contract NAS3-2547)
(NASA-CR-78518; R66SD3012) CFSTI: HC $5.00/MF $1.25 CSCL 14B

A prototype two-loop Cb-1Zr alloy facility, in which sodium is heated by direct resistance in the primary loop and used in a heat exchanger to boil potassium in the secondary, corrosion test loop, was selected for evaluation of refractory alloys in boiling and condensing potassium environments simulating projected space electric power systems. Purification systems and handling equipment were built and operated to provide alkali metals. The purification methods used were filtration, hot trapping and vacuum distillation—the latter method used for potassium only. A complete set of drawings illustrate the alkali metal purification and handling systems. The sodium, potassium and eutectic NaK were analyzed for oxygen by the amalgamation method, and for metallic impurities by emission spectrography. In all cases, the alkali metals used in the loops were of the desired purity as determined by the analyses. R.Ll.

N66-38740# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
METHOD OF PRODUCING GRAPHITE LUBRICANTS
A. S. Fialkov, I. V. Temkin et al 28 Apr. 1965 6 p Transl. nto ENGLISH from the RUSSIAN Patent no. 159808 (Appl. No. 782150/23-4, 11 Jun. 1962) 2 p
(FTD-TT-64-1290; TT-65-62269; AD-615296) CFSTI: HC $1.00/MF $0.50

The object of the invention is a method of obtaining graphite lubricants by means of grinding graphite to the colloidal state. The ground graphite is subjected to thermal treatment at 2,600–3,000°C to increase the antifriction properties. TAB

N66-39016# Joint Publications Research Service, Washington, D. C.
STUDY OF THE COOROSION STABILITY OF VAD-23 ALLOY
V. A. Klimova *In its* Aluminum Alloy Res. in the USSR 27 Sep. 1966 p 87–96 refs (See N66-39006 24-17) CFSTI: $7.30

Temperature of quenching water, additional heating, and cold hardening effects on corrosion are compared for two alloys of the Al–Cu–Li–Cd–Mn system, VAD-23 and D-16, which were tempered and aged at 170°C for 16 hr and at 190°C for 12 hr. In both alloys, increasing from 5 to 10 sec the time required for transfer from the heating medium to the tempering bath leads to corrosion and lowering of strength. Both local and intragranular corrosion are noted when VAD-23 is quenched at 20°C, but only local corrosion is evidenced at higher temperatures; and following artificial aging at 170°C, there is neither intragranular corrosion cracking under stress. Aluminum cladding does not produce complete electrochemical protection of BAD-23 in 3% NaCl solution, and in 1% solution there is no protection at all. Corrosion stability of unclad specimens of both BAD-23 and D-16 is about the same. M.W.R.

N66-39035# Joint Publications Research Service, Washington, D. C.
CORROSION STABILITY OF NEW SINTERED ALUMINUM ALLOYS
V. S. Komissarova, A. F. Kireyeva, N. S. Klyagina, and R. A. Krivenko *In its* Aluminum Alloy Res. in the USSR 27 Sep. 1966 p 285–291 (See N66-39006 24-17) CFSTI: $7.30

Pressed rods of sintered aluminum alloys, with varying degrees of other elements, were investigated to determine their corrosion stability. Most of the alloys had large quantities of silicon, lesser quantities of nickel, and small amounts of other

elements. Two alloys with about 30% silicon exhibited the same stability under atmospheric conditions as an aluminum alloy without any silicon. Strength losses are reported at 28% after three years. Another alloy, with 13.4% Si and 16.25% SiC, has greater corrosion stability than either of the 30% silicon alloys when totally immersed in a 3% solution of NaCl.The high-content Si alloys are found to be effective cathodes. M.W.R.

N66-39039# Joint Publications Research Service, Washington, D. C.

PRODUCTION OF THIN WALLED PIPES FROM SAP BY THE COLD PRESSING METHOD

A. N. Kuzhetsov, G. G. Epshteyn, and P. V. Kishnev *In its* Aluminum Alloy Res. in the USSR 27 Sep. 1966 p 323–330 (See N66-39006 24-17) CFSTI: $7.30

Cold pressing with lubrication is used to produce thin-walled small diameter SAP (sintered aluminum powder) pipes; and the ends of these pipes can be locked without heating. For a 14×1 mm SAP-1 pipe, with extension, specific pressure during drawing is found to be equal to 120 to 130 kg-force/mm^2; and since pressing can take place at the rate of 2 to 4 m/sec, the use of rapid hydraulic or mechanical presses is recommended. Since both pipes and work blanks heat to at least 400° or 460°C during pressing, the pressure required is lowered. While the microstructure of the cold pressed pipes is not clearly striated, a striated structure is developed after drawing. The developed method is considered desirable because it shortens the production cycle, decreases the number of rejects, and increases productivity of labor. M.W.R.

N66-39041# Joint Publications Research Service, Washington, D. C.

CORROSION STABILITY OF SAP MATERIAL

V. S. Komissarova, A. F. Kireeva, M. G. Stepanova, and I. N. Fridlyander *In its* Aluminum Alloy Res. in the USSR 27 Sep. 1966 p 339–352 refs (See N66-39006 24-17) CFSTI: $7.30

Corrosion stability of sintered aluminum powder (SAP) is investigated as a function of aluminum oxide and iron content. It is found that iron content must be limited to 0.2%, since it has an unfavorable effect and quantities greater than this decrease relative elongation under atmospheric conditions by an average of 25 to 30%. Aluminum oxide, which may also be viewed as a cathode inclusion, has a very insignificant effect in 3% NaCl solution. When the SAP is anodized in sulfuric acid, a satisfactory anode film is obtained. M.W.R.

N66-39045# Joint Publications Research Service, Washington, D. C.

HIGH STRENGTH CORROSION RESISTANT ALLOY V91

Ye. I. Kutaytseva, V. S. Komissarova, I. V. Butusova, N. V. Yegorova, and R. P. Usacheva *In its* Aluminum Alloy Res. in the USSR 27 Sep. 1966 p 372–377 refs (See N66-39006 24-17) CFSTI: $7.30

High static and dynamic strength properties and relatively high corrosion stability are found for semifinished products made from V-91 aluminum alloy, which contains Cr, Cu, Mg, Mn, and Zn. Ingots 70 mm in dia were cast by a semicontinuous method, homogenized at 460°C for 24 hr, and then pressed into rods of 10 and 20 mm dia. For alloys containing up to 2.5% Mg, air tempering produces a slightly lower tensile strength than does quenching in water; and relative elongation is relatively unchanged. With increase in Mg content, yield point decreases more during air tempering than with water tempering. Introduction of Cu increases sensitivity to cooling rate during tempering. Corrosion pits occurred following complete immersion of the specimens in 3% NaCl for a period of 3 months; and losses due to fatigue are 28.5% for the V-91 alloy. M.W.R.

N66-39050# Joint Publications Research Service, Washington, D. C.

HEAT TREATMENT OF PARTS MADE DROM AK6 ALUMINUM ALLOY IN HOT MEDIA

N. A. Loktionova, V. I. Kulakov, and V. I. Isayev *In its* Aluminum Alloy Res. in the USSR 27 Sep. 1966 p 420–430 refs (See N66-39006 24-17) CFSTI: $7.30

Mechanical properties, corrosion stability, and microstructure are investigated as a function of heat treatment for pressed work blanks and stampings made from an aluminum alloy, AK-6, which contains quantities of Cu, Mg, Mn, Si, and Ti. During tempering in a hot medium there is a slight decrease in mechanical properties, which is attributed to the decomposition of solid solution along the grain boundaries. As a result, materials with fine grain structures and well-developed substructures are more sensitive to changes in cooling rate than are products with large grain recrystallized structures. Overall corrosion and stress corrosion stability are about the same after tempering in a hot medium as after ordinary tempering followed by artificial aging. Warpings in materials quenched in the hot medium are somewhat fewer than usually occurs, which decreases rejects due to deformation and increases quality. M.W.R.

N66-39105# Marine Engineering Lab., Annapolis, Md.

FRICTION AND WEAR OF COMPOSITE LUBRICATING MATERIALS

G. L. Thomas Jul. 1966 21 p refs

(MEL-28166; AD-636402) CFSTI: HC $1.00/MF $0.50

Solid lubricants present a solution in some applications to the need for safe, effective lubrication in the higher temperature and pressure ranges demanded by Navy machinery. Friction and wear characteristics of self-lubricating-type composite materials have been evaluated for potential high-pressure air compressor application using a bench-scale apparatus. A few of the materials have been used successfully in a nonlubricated cylinder seal application. Author (TAB)

N66-39177# Union Carbide Nuclear Co., Oak Ridge, Tenn. Nuclear Div.

A SPECIAL MACHINE TOOL SLIDE BEARING MATERIAL

Charles Asmanes 20 Jul. 1966 14 p

(Contract W-7405-ENG-26)

(Y-1547) CFSTI: HC $1.00/MF $0.50

Many machine tools at the Oak Ridge Y-12 Plant have been equipped with Teflon wear pads under the slides. The material has minimized the amount of maintenance work and eliminated troublesome lubrication problems. Teflon is easily applied to machine ways, usually by clamping the material under the wiper pads. Author (NSA)

N66-39527*# General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.

MATERIALS FOR POTASSIUM LUBRICATED JOURNAL BEARINGS Quarterly Progress Report No. 10, 22 Jul.–22 Oct. 1965

R. G. Frank, ed. [1965] 171 p refs

(Contract NAS3-2534)

(NASA-CR-72027) CFSTI: HC $5.00/MF $1.00 CSCL 11F

Various candidate bearing materials, exposed to potassium for 1000 hours at 800°, 1200°, and 1600°F were examined metallographically and by X-ray diffraction analyses for microstructural changes or evidence of attack. Only carboloy 999 and Zircoa 1027 exhibited corrosive reactions and showed a transfer of carbon to the Cb-1Zr container wall after 1200°F and 1600°F exposure; a distinct layer of CbC on the ID surface of the encapsulating walls was identified metallographically. Chemical

analyses of the inner 0.020-inch layer in the liquid region of the Cb-1Zr alloy capsule which contained Carboloy 907/Mo-TZM alloy test specimens found a 210 ppm increase in carbon content. The test facility for the liquid potassium friction and wear test rig was modified and almost completed. G.G.

N66-39572# Naval Ordnance Test Station, China Lake, Calif.
THE EFFECT OF HIGH-MOLECULAR-WEIGHT POLYMER ADDITIVES ON THE PERFORMANCE OF A CONICAL DIFFUSER
H. V. L. Patrick Aug. 1966 28 p refs
(NOTS-TP-4154; AD-637305) CFSTI: HC $2.00/MF $0.50

Experiments were conducted to obtain and compare conical-diffuser performance information using plain tapwater and high-molecular-weight polymer solutions. The diffuser exhibited a transitory-type separation with plain water. Test results showed that diffuser performance increased by approximately 7 to 9 percent when using J2-FP guar gum solution concentrations of 1/64 to 1/8 percent over a Reynolds-number range of 55,000 to 75,000. The experiments also revealed that large-scale pressure fluctuations might be greatly decreased by the use of these solutions. (Author) TAB

N66-39764# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
INVESTIGATION OF TECHNOLOGICAL LUBRICANTS BASED ON SALT MIXTURES FOR HOT ROLLING OF TUBES
G. A. Rodionova and Ya. S. Finkel'shteyn 22 Apr. 1966 24 p refs Transl. into ENGLISH from the publ. "Fiziko-Khimicheskie Zakonomernosti Deistviya Smazok pri Obrabotke Metallov Daveniem" USSR, 1963 p 124–135
(FTD-MT-65-118; TT-66-62069; AD-637373) CFSTI: HC $1.00/MF $0.50

The fundamental possibility of the application of salt lubricants for continuous hot rolling of tubes was confirmed. The best properties are possessed by a lubricant with the following composition: 40% zinc chloride, 30% potassium chloride, 30% sodium chloride, 10% (of the weight of the salts) magnesium oxide and 45% (of the salts and filler) water. The pickling time for tubes rolled with a salt lubricant decreases twice as compared to that of tubes rolled with graphite-mazut lubricant. It was found that a salt lubricant remaining on the internal surface of tubes promotes general corrosion of the metal of the tubes. The influence of the quantity of the various fillers and components of the lubricant on the melting and crystallization temperatures, and also the influence of the quantity of diluent on the consistency of the lubricant (determining the covering ability per unit of surface of the mandrel), were established. TAB

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STAR ABSTRACTS

N67-10031# Atomic Energy of Canada, Ltd., Chalk River (Ontario).
PRODUCING THICK OXIDE LAYERS ON Zr–Ti ALLOYS FOR ENHANCED WEAR RESISTANCE IN WATER-LUBRICATED MECHANISMS
R. D. Watson Jun. 1966 27 p refs
(AECL-2537) CFSTI: HC $2.00/MF $0.50

Five Zr–Ti binary alloys having compositions in the range Zr-0.5 wt% Ti to Zr-10 wt% Ti were investigated for oxide-film-forming characteristics in air at temperatures between 300 and 800°C. Under certain conditions a reasonably thick uniform and tightly adherent oxide layer can be formed on all five materials. Black oxide layers up to 0.0035 in. thick can be produced at temperatures of 700 to 800°C; white or off-white layers up to 0.008 in. thick can be formed at temperatures of 350 to 400°C. The titanium content of the alloys has a pronounced effect on the colour, thickness and quality of the oxide layer. About 22 different oxide coatings were wear tested in water at room temperature. A number of the coatings had excellent wear resistance but the coatings produced by heating Zr-10 wt% Ti and Zr-5 wt% Ti in air at 400°C for 65 h were best. A number of oxidized specimens were corrosion tested in water at 260, 177 and 77°C. At 77°C the corrosion resistance was generally very good; at 260°C the corrosion resistance was unsatisfactory. Author

N67-10090# Joint Publications Research Service, Washington, D. C.
LITHIUM CORROSION OF METALS 19 Sep. 1966 47 p refs Transl. into ENGLISH from the book "Metallurgiya i Metallovedeniye Chistykh Metallov, No. V" Moscow, 1960
(JPRS-37701 TT-66-34130 CFSTI: $2.00
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1. CARBON BEHAVIOR IN METAL–LIQUID LITHIUM–CARBON SYSTEMS N. M. Beskorovaynyy, V. K. Ivanov, and M. T. Zuyev p 1–20 refs (See N67-10091 01-17)
2. CORRISION MECHANISM OF CARBON STEELS IN LITHIUM N. M. Beskorovaynyy and V. K. Ivanov p 21–32 refs (See N67-10092 01-17)
3. CORROSION OF CHROMIUM–NICKEL STAINLESS STEEL IN LITHIUM N. M. Beskorovanynyy, V. K. Ivanov, and V. V. Petrashko p 33–41 refs (See N67-10093 01-17)

N67-10092# Joint Publications Research Service, Washington, D. C.
CORROSION MECHANISM OF CARBON STEELS IN LITHIUM
N. M. Beskorovaynyy and V. K. Ivanov *In its* Lithium Corrosion of Metals 19 Sep. 1966 p 21–32 refs (see N67-10090 01-17) CFSTI: $2.00

Results are reported from metallographic investigations of the processes which take place when carbon steels are in contact with liquid lithium. Thermodynamic calculations indicate that, up to temperatures of 723°C, the destruction of carbon steels by corrosion is due to the reactive penetration of lithium into steel as a result of an interaction with the cementite. It is also pointed out that the formation of lithium carbide and its subsequent dissolution are accompanied by an increase in volume. The resulting stresses lead to plastic deformation of the corrosion zone. Different changes in volume at the surface and in depth of the corrosion zone lead to the appearance of a complex stressed state in the specimens which affects the course of the corrosion process and the shape of the lithium diffusion curves. A.G.O.

N67-10093# Joint Publications Research Service, Washington, D. C.
CORROSION OF CHROMIUM-NICKEL STAINLESS STEEL IN LITHIUM
N. M. Beskorovaynyy, V. K. Ivanov, and V. V. Petrashko *In its* Lithium Corrosion of Metals 19 Sep. 1966 p 33–41 refs (See N67-10090 01-17) CFSTI: $2.00

Results are presented from studies of the low corrosion resistance of chromium-nickel steel in lithium. It is reported that the corrosion of austenite chromium-nickel steel in contact with lithium at 700°C is due to a reduced content of chromium and nickel in the surface layer. Consequently, this layer becomes porous and impairs the plastic properties of the steel. It is also noted that carbon impurities in lithium significantly affect the degree of steel corrosion in lithium and reduce the concentration of chromium and nickel in the surface layers. A.G.O.

N67-10154# Metaalinstituut TNO, Delft (Netherlands).
INVESTIGATION OF THE CORROSION-PREVENTIVE PROPERTIES OF VCI PAPER [ONDERZOEK VAN HET CORROSIEWERENDE GEDRAG VAN VCI-PAPIER]
J. W. Boon 8 Jun. 1966 15 p In DUTCH
(TDCK-46179; C-66-477) CFSTI: HC $1.00/MF $0.50

The investigation was to establish standards and regulations for the selection and procurement of corrosion-preventive papers for military use. Pertinent American and German military specifications are reviewed, and seven test methods to determine various characteristics of the papers are discussed. The tests involve the prevention of corrosion of copper, steel, and aluminum. An original test arrangement using air and water vapor is described in detail, and ten Dutch and German paper samples were tested by this method. Detailed test results are presented. Transl. by K.W.

N67-10528# Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.
THE ROLE OF DISLOCATIONS IN TRANSGRANULAR STRESS CORROSION CRACKING OF AUSTENITIC STAINLESS STEELS
Mc Intyre R. Louthan, Jr. Mar. 1966 26 p refs
(Contract AT(07-2)-1)
(DP-1008) CFSTI: HC $2.00/MF $0.50

Studies that correlate dislocation substructure with transgranular stress corrosion cracking in austenic stainless steel are summarized. Evidence is presented to show that the primary role of dislocations in the mechanism of cracking is to provide a continuous supply of localized anodic regions for selective electrochemical attack. The results show that cracking occurs preferentially on the {111} family of planes and that dislocation movement, and therefore deformation, is required in the cracking process. Possible methods of reducing transgranular stress corrosion cracking include any process or alloy change that either inhibits dislocation movement, promotes cross slip, or reduces the tendency for corrosion. Author (NSA)

N67-10625# California Univ., Berkeley. Coll. of Engineering.
FRICTION IN ULTRAHIGH VACUUM. PRELIMINARY TESTS ON ALUMINUM SURFACES
J. Frisch, R. D. Nelson, and P. Pfaelzer Apr. 1966 17 p refs
(Contract W-7405-ENG-48)
(MD-66-2; UCRL-13212) CFSTI: HC $1.00/MF $0.50

Three preliminary friction tests on aluminum specimens were conducted in the ultrahigh vacuum chamber to check the operational performance of equipment and instrumentation. These tests demonstrated the suitability and capability of the equipment. The calibration and addition of a more efficient strain gauge dynamometer in the vacuum chamber as well as some changes in test procedure were suggested by these tests. NSA

N67-10638# Commissariat a l'Energie Atomique, Saclay (France). Departement de Physico-Chemie.
ADSORPTION STUDIES IN A FLUORINATING ATMOSPHERE [ETUDE DE L'ADSORPTION EN ATMOSPHERE FLUORANTE]
Jean-Jack Abassin, Paul Barberi, Yves Guillouet, Olivier Hartmanshenn, Jacques Lambard et al Mar. 1966 78 p In FRENCH
(CEA-R-2932)

Aspects of the adaptation of conventional or non-conventional apparatus to the measurement of the physical and chemical adsorption of corrosive fluorine-containing gases are reviewed. Discussions are included on thermogravimetry, volumetry, use of radioactive tracers, calorimetry, hertzian spectroscopy, and infrared spectroscopy. In each of these cases, problems of corrosion call for the use of special techniques which require the extensive use of pure Ni and Al or their alloys. Diagrams of the apparatus and some examples of applications are given, together with some details of the performances. Author (NSA)

N67-10775# Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.
STRESS-CORROSION CRACKING OF CARBON STEEL IN SIMULATED WASTE SOLUTIONS
L. P. Costas, M. L. Holzworth, and W. C. Rion Jun. 1966 33 p refs
(Contract AT(07-2)-1)
(DP-1023) CFSTI: HC $2.00/MF $0.50

A laboratory corrosion test program was carried out to determine the cause of cracking failure in carbon steel tanks used for the storage of radioactive waste. Welded test specimens (carbon steel plate, 36 inches square×1/2-inch thick, ASTM A285 Grade B) suffered stress-corrosion cracking in simulated waste solutions containing nitrate. The cracks induced in the laboratory were similar to the cracks observed in the plant. Full stress relief, which prevented stress cracking of the specimens in the test solutions, should be considered for future tanks of this type. Author (NSA)

N67-10992# Watervliet Arsenal, N. Y. Benet Labs.
EVALUATION OF ELECTRODEPOSITED COPPER, LEAD, AND LEAD-TIN ALLOY (93-7%) BEARING SURFACES FOR SWAGING CANNON BORES
V. Peter Greco Apr. 1966 29 p refs
(WVT-6608; AD-637183) CFSTI: HC $2.00/MF $0.50

Electrodeposits of copper, lead, and lead-tin were evaluated as bearing surfaces for swaging steel cylinder bores. Drive pressure-time curves for the traveling mandrel are reviewed and discussed. The relationship between bearing surface characteristics of swaged cylinders and the behavior of the traveling mandrel were established. Metallographic and x-ray (back reflection Laue Method) examinations are discussed and photographs are shown to exemplify bearing surface characteristics after swaging. Contrasting results are shown for the behavior of copper (exemplifying stick-slip motion) as compared to lead and lead-tin surfaces. Some results are also reported for tin and zinc electrodeposits. Average pressure-time curves from production runs are presented and compared with experimental lead and lead-tin tests. The evaluation has shown that lead is generally the best bearing material for the swaged tubes examined Author (TAB)

N67-11199# Army Weapons Command, Rock Island, Ill. Research and Engineering Div.
RADIOMETRIC STUDY OF THE WEAR CHARACTERISTICS OF DRY FILM LUBRICANTS Final Report
Elizabeth A. Jennings and Stanley L. Eisler Aug. 1966 15 p refs
(RIA-66-2446; AD-638800) CFSTI: HC $1.00/MF $0.50

The wear life of dry film lubricants as related to percent coating loss was studied by use of a radioactive tracer technique. The contribution to the total wear life by various combinations of the three basic ingredients--molybdenum disulfide, antimony trioxide, and dibasic lead phosphite was studied. Tests were run on a Falex Lubricant Tester to determine the percent coating loss of different formulations for various time periods. Percent coating loss was determined from counting rates of the pins, coated with tagged formulations, before and after testing. The test results indicated a linear relationship between percent coating loss and length of test. It was found that a prediction of the relative wear lives of different formulations could be made on the basis of the percent coating loss results, determined after one hour of testing. TAB

N67-11217 RAND Corp., Santa Monica, Calif.
THE HYDRODYNAMICS OF A NONISOTHERMAL LUBRICANT LAYER

M. E. Podol'skiy *In its* Proc. of the 2d All-Soviet Union Conf. on Heat and Mass Transfer, Vol. I Aug. 1966 p 151–163 refs (See N67-11201 02-33) Available from Calif. Univ. Press, Los Angeles: $7.00

For application to sliding thrust bearings, an approximate solution is carried out for the hydrodynamic and energy-balance equations, taking into account the change in the viscosity along the length and the thickness of the layer. The boundary conditions for the temperature were selected by analyzing the propagation of heat in a rod. A more detailed study was made of the flow of the lubricant between parallel friction surfaces. The formulas obtained show that the friction surfaces are attracted to each other due to the temperature dependence of the viscosity. Among other results, it was found that the nonisothermal flow of oil in a gap of constant thickness, under the specified conditions, leads to the emergence of forces which draw the friction surfaces together. R.Ll.

N67-11245# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
AUTOMOBILE INDUSTRY Selected Articles
6 Jun. 1966 33 p Transl. into ENGLISH from Avtomob. Prom. (Mashgiz). 1964 p 37–40, 45–47
(FTD-TT-65-1856; TT-66-62282; AD-639153) CFSTI: HC $2.00/MF $0.50

CONTENTS:

1. RELATIVE EFFECTIVENESS OF VARIOUS TYPES OF CHROMIUM COATINGS P. I. Zemskov p 1–16 refs (See N67-11246 02-15)
2. HIGH ENERGY IGNITION SYSTEM FOR STARTING A GAS TURBINE ENGINE A. S. Shteynberg p 17–27 (See N67-11247 02-15)

N67-11246# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
RELATIVE EFFECTIVENESS OF VARIOUS TYPES OF CHROMIUM COATINGS
P. I. Zemskov *In its* Automobile Ind. 6 Jun. 1966 p 1–16 refs (See N67-11245 02-15) CFSTI: HC $2.00/MF $0.50

Dense chromium coating after knurling possesses good antifriction properties. Dense coating after knurling has high wear resistance and wears off little of the surface conjugated with it. Dense coating protects the detail against corrosion. The process of dense chromium plating after knurling is technologically simple, while the process of porous chromium plating is carried out by a strictly definite regime and the slightest deviations from same lead to a reduction in antifriction and wear resistant properties of the given coating. Author (TAB)

N67-11346*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WEAR AND FRICTION OF VARIOUS POLYMER LAMINATES IN LIQUID NITROGEN AND IN LIQUID HYDROGEN
Donald W. Wisander, Lawrence P. Ludwig, and Robert L. Johnson Washington, NASA, Nov. 1966 15 p refs
(NASA-TN-D-3706) CFSTI: HC $1.00/MF $0.50 CSCL 11I

Wear and friction of polymer laminates were determined in liquid nitrogen and liquid hydrogen. Polymers included polytetrafluoroethylene (PTFE), phenol formaldehyde (phenolic), epoxy-formaldehyde (epoxy), and melamine formaldehyde (melamine); fabrics included glass, graphite, cotton, and nylon. Wear and friction experiments were conducted with a 3/16-inch-radius hemispherically-tipped polymer laminate rider sliding on the flat surface of a rotating 304-stainless-steel disk. The sliding velocity was maintained at 2300 feet per minute. The polymer laminate riders were under a 1000-gram load against the disk. The results of the investigation indicate that a laminate of graphite fabric and phenolic resin is a potentially useful material for sliding contact in liquid nitrogen and that a laminate of glass fabric and PTFE resin is useful in liquid hydrogen. Wear and friction of the laminates were appreciably higher in liquid hydrogen than in liquid nitrogen. Author

N67-11679# Franklin Inst., Philadelphia, Pa. Labs. for Research and Development.
MATHEMATICAL ANALYSIS OF THE LAMINATED ELASTOMERIC BEARING Final Report
R. Clyde Herrick May 1966 120 p refs
(Contract DA-44-177-AMC-110(T))
(F-B2140-1; USAAVLABS-TR-66-21; AD-637213) CFSTI: HC $4.00/MF $0.75

The purpose of this study was the establishment of analytical design procedures for laminated elastomeric bearings. This was approached with the application of the linear mathematical theory of elasticity and later with gonlinear large-deformation elasticity theory. The linear theory yielded analytical approximations that are close to exact solutions and which are easily applied and evaluated. This analysis of one typical lamination yields the distribution of stress and deformation in the elastomer between 'rigid' metal lamina. However, the limits of the linear elasticity theory are exceeded for greater than small bearing loads, indicating the need for the application of the more comprehensive large-deformation elasticity theory. The large-deformation theory was stated and the equilibrium equations were derived, but the solution of these equations was not carried out Author (TAB)

N67-11719# Atomics International, Canoga Park, Calif.
A DIGITAL COMPUTER STUDY OF THE DYNAMICS OF THE COMBINED ROTATING UNIT SHAFT-BEARING SYSTEM
J. M. Howard 15 Jul. 1966 38 p refs
(Contract AT(11-1)-GEN-8)
(NAA-SR-11944) CFSTI: HC $2.00/MF $0.50

The objectives, method of approach, and results of a digital computer rotordynamic analysis of the SNAP 2 Combined Rotating Unit-V are summarized. Bearing characteristics are in the form of curve fit equations based on empirical data. The effects of shaft bending, differences in fabrication and balancing tolerances, and varying orientation of the rotating magnetic load are evaluated. Author (NSA)

N67-11761*# Israel Program for Scientific Translations, Ltd., Jerusalem.
TITANIUM AND ITS ALLOYS. PUBLICATION NO. 10: INVESTIGATION OF TITANIUM ALLOYS
I. I. Kornilov, ed. 1966 444 p refs Transl. into ENGLISH of the publ. "Titan i Ego Splavy. Issledovaniya Titanovykh Splavov" Moscow, Izd. AN SSSR, 1963 Papers presented at the 2d Conf. on the Theoret. and Exptl. Invest. of Titanium Alloys, Moscow, Mar. 1962 Published for NASA and NSF
(NASA-TT-F-362; TT-65-50139) CFSTI: HC $7.00/MF $2.00 CSCL 11F

Conference papers on the reaction of titanium with other metals and with gases, the structure of titanium alloys, and their corrosion, mechanical, and technological properties are presented. For individual titles see N67-11762–N67-11808.

N67-11780*# Israel Program for Scientific Translations, Ltd., Jerusalem.
THE CORROSION RESISTANCE OF TITANIUM ALLOYS TO VARIOUS MEDIA IN THE CHEMICAL AND PHARMACEUTICAL INDUSTRIES

F. N. Tabadze, S. N. Mandzhgaladze, I. N. Lordkipanidze, and T. S. Dashniani *In its* Titanium and its Alloys 1966 p 158–161 (See N67-11761 02-17) CFSTI: HC$7.00/MF$2.00

The corrosion resistances of VT-1, AT-3, AT-4, AT-6, AT-8, OT-4, and OT-40 titanium alloys were investigated in extracts and tinctures of galenica, and compared with the corrosion resistances of tinned copper and austenitic chromium nickel stainless steel. Results show that in tinctures of iodine, ammonium anisate, pectoral elixir, and ginseng, the corrosion resistance of AT alloys is 10 times higher than that of tinned copper. The corrosion resistance of AT alloys in extracts of digolen-neo, water pepper, and satureia hortensis is 15 times greater than that of tinned copper. Experiments conducted with aqueous solutions of tannin and gallic acid showed that AT alloys have a corrosion resistance 90 times higher than that of VT-1 alloy, 300 times higher than that of tinned copper, and 220 times higher than that of 1 Kh18N9T steel. Solutions of galencia in contact with OT-4 and OT-40 alloys caused a leaching out of manganese. R.N.A.

N67-11781*# Israel Program for Scientific Translations, Ltd., Jerusalem.

CORROSION RESISTANCE OF AT TITANIUM ALLOYS TO MEDIA IN THE FOOD INDUSTRY

F. N. Tabadze and T. A. Lashkhi *In its* Titanium and its Alloys 1966 p 162–166 (See N67-11761 02-17) CFSTI: HC $7.00/MF $2.00

Corrosion tests were conducted under both laboratory and industrial conditions to determine the corrosion resistance of AT-3, AT-4, AT-6, and AT-8 titanium alloys in the presence of some characteristic foods. Results showed that all the alloys have good corrosion resistance to acetic and formic acids, as well as to technical solutions used in the wine, canned food, and tea industries. They also have good corrosion resistance to juices, pickles, and stewed fruits, and do not affect the chemical or physical properties of foods. The high corrosion resistance of AT-3 and AT-8 alloys was demonstrated in the production of caffeine, tartaric vinegar, and in cooling solutions used in breweries. The AT titanium alloys show great promise for use as equipment and apparatus in the food industry. R.N.A.

N67-11784*# Israel Program for Scientific Translations, Ltd., Jerusalem.

ELECTROCHEMICAL AND CORROSION INVESTIGATIONS OF Ti-Al ALLOYS

F. N. Tabadze, S. N. Mendzhgaladze, T. S. Dashniani, I. N. Lordkipanidze, and L. F. Tavadze *In its* Titanium and Its Alloys 1966 p 186–188 refs (See N67-11761 02-17) CFSTI: HC $7.00/MF$2.00

A study was conducted on the electrochemical and corrosion resistant properties of 19 Ti-Al alloys with an Al content ranging from 0.5 to 38.5 weight %. The alloys were heat treated and exposed to corrosive media, including sulfuric acid, hydrochloric acid, nitric acid, and sodium chloride. Results show that alloys with up to 37.5 weight % Al are resistant to nitric acid except those with 6 to 7% Al which are uniformly attacked at a rate of 1.42 mm/yr. Only alloy groups with up to 6% Al, with 10 to 12% Al, or with more than 36% Al are sufficiently resistant ot sulfuric and hydrochloric acids. The notable variations in the electrochemical and corrosion properties of the Ti-Al alloys indicate that the latter contain phases which are more negative than the α-Ti solid solution. R.N.A.

N67-11785*# Israel Program for Scientific Translations, Ltd., Jerusalem.

CORROSION RESISTANCE AND ELECTROCHEMICAL BEHAVIOR OF TITANIUM AND ITS ALLOYS IN SOLUTIONS OF INORGANIC ACIDS CONTAINING OXIDATION AGENTS

F. A. Orlova and T. A. Tumanova *In its* Titanium and its Alloys 1966 p 189–198 refs (See N67-11761 02-17) CFSTI: HC $7.00/MF$2.00

The electrochemical behavior of titanium and its alloys was studied in a specially designed electrolytic unit. Determinations were made of the corrosion velocity of titanium, the dependence of the potential on the duration of exposure, and the relation between the degree of corrosion and the nature of the oxidation agent. Results showed that only active oxidation agents such as humid chlorine and nitric acid can bring about a passivation of titanium in solutions of hydrochloric and sulfuric acids. Concentration and temperature ranges at which titanium and its alloys are resistant in solutions of hydrochloric and sulfuric acid containing chlorine were determined. Titanium is easily passivated in an 18% solution of hydrochloric acid at 90°C if the medium contains from 0.5 to 1.0% nitric acid. An increase in nitric acid up to 10% has almost no effect on the Ti potential, but at 20% HNO_3 the Ti potential rises markedly. Only the Ti alloy with 20% Ta is corrosion resistant at 90°C in an 18% solution of hydrochloric acid saturated with chlorine. Under these conditions the alloy's potential is positive while the potential of the unalloyed titanium is negative. R.N.A.

N67-11804*# Israel Program for Scientific Translations, Ltd., Jerusalem.

AT-3, AT-4, AT-6, AND VT-3-1 TITANIUM ALLOYS USED IN THE PRODUCTION OF COMPRESSOR ROTORS (IMPELLERS) OPERATING IN DIFFERENT CORROSIVE MEDIA

N. I. Belan, M. S. Borisova, B. M. Idel'chik, and A. A. Chikurova *In its* Titanium and its Alloys 1966 p 344–353 (See N67-11761 02-17) CFSTI: HC$7.00/MF$2.00

Heat treatment under optimum conditions does not affect the mechanical properties of several forgings of titanium alloys with varying amounts of Al, Cr, Mo, Si, Fe, and/or B. Plasticity increases when temperature is decreased during short-term tension tests; and impact strengths of these alloys when temperatures are decreased between +20 and −180°C. High corrosion resistance to aqueous solutions saturated with hydrogen sulfide, hydrochloric acid solutions, and certain industrial atmospheres is exhibited by most of the alloys; and results with regard to corrosion resistance are presented for various temperatures, contact solutions, and other conditions. Time to failure of the titanium alloys, into which hydrogen was introduced by electrolysis simultaneously with tensile stresses between 40 and 55 kg/mm^2 varies from 21 to 50 hours. M.W.R.

N67-11813*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FILM-TRANSFER STUDIES OF SEVEN BALL-BEARING RETAINER MATERIALS IN 60°R (33°K) HYDROGEN GAS AT 0.8 MILLION DN VALUE

David E. Brewe, Herbert W. Scibbe, and William J. Anderson Washington, NASA, Nov. 1966 27 p refs

(NASA-TN-D-3730) CFSTI: HC$1.00/MF$0.50 CSCL 13I

Seven self-lubricating retainer materials (a laminated glass cloth with polytetrafluoroethylene (PTFE) binder, a glass-fiber–molybdenum disulfide-filled PTFE, a glass-fiber-filled PTFE, a bronze-filled PTFE, copper–PTFE–tungsten diselenide composite, a silver–PTFE–tungsten diselenide composite, and a molybdenum disulfide-filled polyimide) were evaluated in 40-millimeter-bore ball bearings operating in hydrogen gas at 60°R (33°K). The bearings were operated at 20,000 rpm with a 200-pound (890 N) thrust load for total times to 10 hours. Individual bearing runs were of approximately 2-hour durations. The formation and subsequent life histories of the transfer films were studied and evaluated from highly magnified profile traces of the bearing inner-race grooves. The wear and mechanical integrity of the retainer materials were determined by visual observations and weight-differential measurements after each 2-hour run. Author

N67-11830# Joint Publications Research Service, Washington, D. C.

KINETICS OF THERMOGALVANIC CORROSION AND THE CALCULATION OF THE PARAMETERS OF THERMO-GALVANIC COUPLES

A. Ya. Shatalov, S. A. Kaluzhina, and I. K. Marshakov 15 Nov. 1966 9 p refs Transl. into ENGLISH from Izv. Vyssh. Ucheb. Zaved., Khim. i Khim. Tekhnol. (Moscow), no. 6, 1965 p 931–935 (JPRS-38648; TT-66-35073) CFSTI: $1.00

An expression was developed for the value of the thermogalvanic current based on electrochemical kinetics, and experiments to verify the equation are described. It was assumed that the only process of anode direction on the hot and cold electrodes is the ionization of the metal, and that the cathode process consists of hydrogen ions in the discharge or in the precipitation of identical metal ions from the solution. The experiments investigated the effects of the temperature difference between the electrodes, the galvanic corrosion of various metals, and the degree of localization of corrosion losses when the couples are short circuited. It was established that as the temperature difference becomes greater the localization of the corrosion losses on the anode increases in normal couples, and decreases in reversed couples. N.E.N.

N67-11904# Aktiebolaget Atomenergi, Stockholm (Sweden).

INTERCRYSTALLINE STRESS CORROSION CRACKING OF INCONEL 600 INSPECTION TUBES IN THE AGESTA REACTOR

B. Groenwall, L. Ljungberg, W. Huebner, and W. Stuart Aug. 1966 26 p refs

(AE-245) CFSTI: HC $2.00/MF $0.50

Intercrystalline stress corrosion cracking has been observed in three so-called inspection tubes of Inconel 600 in the Ågesta reactor. The cracks developed on the outside surface of the tubes, which were exposed to 217°C light water containing normally 1 to 4 ppm LiOH or KOH and small amounts of oxygen and chloride. These elements may have enriched in the crevices at which most of the cracking occurred. Other factors which are thought to have contributed to the cracking are tensile stresses of the order of the 0.2% offset yield strength built up during shop welding, and a relatively high carbon content of the alloy (0.08%) giving rise to heavy precipitation of carbides inside and between the grains. The tube material had an unusually high yield strength. Irradiation and surface contamination were found to be of no importance. Author

N67-11942*# Franklin Inst., Philadelphia, Pa. Research Labs.

DYNAMIC STABILITY OF ROTOR-BEARING SYSTEMS

Edgar J. Gunter, Jr. (Va. Univ.) Washington, NASA, 1966 234 p refs

(Contract NAS3-6473)

(NASA-SP-113) GPO: HC $1.00; CFSTI: MF $1.25 CSCL 13I

Discussed are general conditions which can lead to nonsynchronous precession in a rotor system; considered were shaft whirling, oil film whirl, resonance whip, and half-frequency whirl. In the analysis, general equations of motion are developed to include rotor and foundation flexibility, internal and external damping, rotor and bearing mass, and fluid film bearings. The rotor threshold of stability is determined and from the various stability charts developed it was concluded that improved rotor stability characteristics can be obtained by a proper foundation design. G.G.

N67-11944*# National Aeronautics and Space Administration, Washington, D. C.

LUBRICATION, CORROSION AND WEAR—A CONTINUING BIBLIOGRAPHY WITH INDEXES, APRIL 1965–AUGUST 1966

Oct. 1966 302 p refs

NASA-SP-7020(01)) CFSTI: HC $3.75/MF $1.50 CSCL 13H

This supplement to the original issue of the continuing bibliography on "Lubrication, Corrosion and Wear" presents a selection of annotated references to unclassified reports and journal articles that have been announced in Scientific and Technical Aerospace Reports, or in International Aerospace Abstracts. References reflect the design and development of equipment and materials for use in a space environment and cover such topics as lubricating systems; design and performance of bearings; special applications of lubricants; stress corrosion and fatique cracking in metals and alloys; friction and wear characteristics of materials, and types of corrosion and techniques of corrosion prevention. A subject index and a personal author index are included. G.G.

N67-11997# Metaalinstituut TNO, Delft (Netherlands). Afdeling Corrosie.

INVESTIGATION OF THE CORROSION-PREVENTIVE CHARACTERISTICS OF TEMPORARY PRESERVING AGENTS [ONDERZOEK NAAR THE CORROSIEWERENDE GEDRAG VAN TIJDELIJKE PRESERVEERMIDDELEN]

3 Aug. 1966 23 p refs In DUTCH

(TDCK-46171; Rept.-1) 6-66-669) CFSTI: HC $1.00/MF $0.50

The tests were specifically conducted to evaluate the suitability of these corrosion-preventive agents for military use. Seven standard agents now in military use and samples of three new products that were submitted by the manufacturers were evaluated. The agents were of the following types: thin oils with inhibitors or thinners; vaselines; stiff plastic substances; volatile detergent oils; bitumen solutions; and polyvinyl butyral compounds. The samples were tested on steel plates for atmospheric exposure, salt spray, humidity with SO_2 contents, and intermittent submersion in NaCl solution. Effective lengths of protection and quality ratings of the agents are shown in tables. Also presented is a brief report on the preparation and evaluation of waterproofing varnishes. Transl. by K.W.

N67-11998# Netherlands Research Centre TNO for Shipbuilding and Navigation, Delft. Corrosion and Antifouling Dept.

CORROSION, SHIPBOTTOM PAINTS [CORROSIE, HUIDVERVEN]

H. C. Ekama Apr. 1966 13 p refs In DUTCH; ENGLISH summary

(TDCK-46170) CFSTI: HC $1.00/MF $0.50

The use of good surface preparation and shop coating before plating steel used in ship hulls in order to prevent corrosion and deterioration of the paints and antifouling compositions used to keep the hull in good condition, are discussed. L.S.

N67-11999# Rubber Research Inst. TNO, Delft (Netherlands).

SWELLING TESTS WITH CABLE INSULATING MATERIALS IN FOUR TYPES OF OIL [ZWELPROEVEN MIT MANTELS VAN EEN AANTAL KABELS IN 4 OLIESOORTEN]

J. J. Kruys, G. J. Flim, and E. A. Walraad 14 Jun. 1966 5 p refs In DUTCH

(TDCK-45714; MAR-6616) CFSTI: HC $1.00/MF $0.50

The swelling of eight electric cable insulation samples was measured after submersion at 50°C in four different types of oil for periods of 1 week, 4 weeks, and 8 weeks. The oil was provided by the Dutch Navy and included one diesel oil, two lubrication oils, and one hydraulic oil. The test results are presented in tables. Transl. by K.W.

N67-12070*# Battelle Memorial Inst., Columbus, Ohio.

INVESTIGATION, TESTING, AND SELECTION OF SLIP-RING LEAD WIRES FOR USE IN HIGH-PRECISION SLIP-RING CAPSULES Final Report

R. H. Ernst, D. N. Williams, and E. S. Bartlett 15 Sep. 1966 115 p refs
(Contract NAS8-20188)
(NASA-CR-80081) CFSTI: HC $4.00/MF $0.75 CSCL 13H

Since galvanic corrosion was a serious problem in the silver-plated copper wires used in slip-ring assemblies of the Saturn guidance and control systems, thirty silver alloys were evaluated in compliance with lead-wire requirements. The best three alloys (Ag–1.5 Cu, Ag–0.2 Ni, and Ag–1 Cu–0.2 Ni) were scaled up to 19-strand, 42-gage, Teflon-insulated lead wires for complete evaluation. It was found that the silver alloys had excellent corrosion resistance; they were very fabricable; they were resistant to reactions with Teflon during curing of the insulation; their properties were not affected by exposure to air during the Teflon-curing cycle; and they met the ultimate strength and electrical conductivity requirements. Details are given on selection of candidate alloys, experimental procedures, results of studies of laboratory-processed wire, results of the alloy scale-up program, and evaluation of slip-ring lead wires. Surveys of commercial silver alloys and of alloying effects are also included. L.E.W.

N67-12093*# General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.
POTASSIUM CORROSION TEST LOOP DEVELOPMENT Quarterly Progress Report, Period Ending Apr. 15, 1966
E. E. Hoffman, ed. 22 Jul. 1966 76 p refs
(Contract NAS3-2547)
(NASA-CR-72042; QPR-11) CFSTI: HC $2.50/MF $0.75 CSCL 14B

The prototype test loop is intended for the evaluation of refractory alloys in boiling and condensing potassium environments which simulate project space electric power systems. Progress in a 5000-hour operation test is reported. Sodium and potassium were distilled from the loop components and samples were taken from each circuit during the draining operation. Calibration of the slack diaphragm pressure transducers and their response characteristics are discussed. The test loop proper and the components were inspected for system degradation or contamination. The Mo–TZM alloy turbine simulator nozzle and blade specimens were evaluated for corrosion or erosion. Evaluation of the test results failed to disclose any significant changes in the condition of the prototype corrosion loop. A preliminary chemical analysis of Cb–1Zr foil and tube specimens indicated that only slight oxygen contamination resulted from exposure in the vacuum environment during the 5000-hour test. K.W.

N67-12321# Columbia Univ., New York. Lubrication Research Lab.
AN EXPERIMENTAL STUDY OF AIR-LUBRICATED FOILS WITH REFERENCE TO TAPE TRANSPORT IN MAGNETIC RECORDING
L. Licht Aug. 1966 161 p refs
(Contract Nonr-4259(14))
(Rept.-7; AD-638010) CFSTI: HC $5.00/MF $1.00

An elastic foil under tension is wrapped partly around a rotating cylinder and is supported on a thin film of air. Capacitance probes, coincident with the surface of the cylinder, scan the air gap along the arc of wrap. The cylinder can be traversed across the width of the stationary foil, so that the topography of the air gap can be determined from a series of circumferential scans. Experimental results are compared quantitatively with theoretical predictions for the perfectly flexible and for the elastic foil-bearing of infinite width. A comparison is also made with theory, for the case when the angle of wrap is small and the entrance and exit transition zones merge. The effect of foil and gap width on side leakage is illustrated. The major part of the study deals with elastic foil-bearings of finite width and with the characteristic 'edge effect' in particular. The influence of various parameters on the nature of the displacement field of foils is demonstrated and related to recent analyses. Author

N67-12387# Virginia Polytechnic Inst., Blacksburg. Dept. of Metals and Ceramic Engineering.
THE RELATIONSHIP OF NITROGEN CONTENT OF A HIGH PURITY 20-20 AUSTENITIC STAINLESS STEEL TO STRESS CORROSION Final Report
John F. Eckel, R. E. Smith, and A. B. Greene 30 Jul. 1966 25 p refs
(Grant DA-ARO(D)-31-124-G441)
(AROD-4099-2; AD-639216) CFSTI: HC $1.00/MF $0.50

The problem of stress corrosion cracking in austenitic stainless steels containing nitrogen has been studied, using a high purity 20 percent chromium, 20 percent nickel steel. The approach to the problem consisted of the determination of physical characteristics of the alloy as affected by nitrogen and the possibilities of nitrogen causing aging in such steels which could be associated with susceptibility to stress corrosion cracking. Specimens containing varying amounts of nitrogen were prepared and subjected to a dilatometric analysis on heating to 180C, and the volume changes were studied, to observe solid state reactions in the alloy in this temperature range. A unique dilatometer was designed and constructed which permits the applications of constant tensile stresses over the range of temperature of interest. Specimens were tested in this instrument at various stress levels and at a constant heating rate. Internal friction measurements were also made by means of a torsional pendulum in the temperature range from ambient room temperature up to 300C. Author (TAB)

N67-12431# Joint Publications Research Service, Washington, D. C.
REDUCTION OF FRICTION IN DEVICES BEARINGS
I. M. Sivokonenko, K. N. Yavlenskiy, and L. V. Semenov *In its* Izv. VUZov: Instr. Bldg. 12 Oct. 1966 p 142–146 refs (See N67-12401 03-14) CFSTI: $4.00

The result is presented of an experimental investigation of the moment of frictional forces in conventional radial-support bearings and in bearings with a three-point contact, with forced motion of the external or internal rings. Author

N67-12468# Aktiebolaget Atomenergi, Stockholm (Sweden).
CHEMISTRY
Erik Linden *In its* Operating Experience at the Agesta Nucl. Power Sta. Sep. 1966 p 56–65 (See N67-12461 03-22) CFSTI: HC $4.00/MF $0.75

With the exception of the fuel cladding the primary system is made of or lined with stainless steel. The aim of water chemistry control is, therefore, to avoid stress corrosion and other types of local attack, reducing contamination by active corrosion products and avoiding the accumulation of these products, at places as in valves and narrow flow passages, to an extent dangerous to the correct functioning of plant equipment. To assist herein all surfaces in contact with water have been given a high surface finish and a high standard of purity has been maintained in the light and heavy water used. The heavy water systems are closed circuits and water chemistry control is achieved by the use of ion exchangers in conjunction with chemical additives. Author

N67-12635# Aktiebolaget Atomenergi, Stockholm (Sweden).
FAILURE OF INCONEL INSPECTION TUBES
Oct. 1966 4 p
(AE-246, suppl.) CFSTI: HC $1.00/MF $0.50

Results are summarized of an investigation of a heavy water leakage due to cracks in three Inconel 600 inspection tubes at the Agesta Nuclear Power Station. The failures encountered show that Inconel 600 under certain conditions may be susceptible to intercrystalline stress corrosion cracking in alkaline high temperature water. R.N.A.

N67-12778# Joint Publications Research Service, Washington, D. C.
INVESTIGATION OF GYROSCOPE RESTING ON SPHERICAL BEARING
O. A. Ivanov and V. L. Rapoport *In its* Izv. VUZov: Instr. Bldg., Vol. IX, No. 4 22 Nov. 1966 p 75–79 refs (See N67-12761 03-14) CFSTI: $5.00

Under consideration is a high speed gyroscope resting with a cone-shaped cup on a stationary ball. Expressions are derived for the moments of forces applied by the ball on the gyroscope. Author

N67-12782# Joint Publications Research Service, Washington, D. C.
MEASURING RESIDUAL STRESSES BY USING VIBRATIONS TO REDUCE FRICTION
I. P. Moiseyev *In its* Izv. VUZov: Instr. Bldg., Vol. IX, No. 4 22 Nov. 1966 p 98–100 refs (See N67-12761 03-14) CFSTI: $5.00

A unit is described for measuring the residual stresses by using the method of etching and vibrations to reduce the effect of friction in the moving joints. Author

N67-12866# Los Alamos Scientific Lab., N. Mex.
LEACHING OF URANIUM BY HYDROGEN CHLORIDE FROM PYROLYTIC-CARBON-COATED URANIUM DICARBIDE BEADS
Maynard E. Smith, John H. Cappis, and Glenn R. Waterbury 6 Jul. 1966 32 p refs
(Contract W-7405-ENG-36)
(LA-3488) CFSTI: HC $2.00/MF $0.50

The corrosive action of HCl on pyrolytic-C-coated UC_2 beads was investigated over the range 1600 to 2100°C. It was necessary to develop an apparatus that could withstand the high temperature and the corrosive HCl–He mixture. A measured volume of the gas mixture was passed through each sample at temperatures ranging from 1600 to 2100°C. The UCl_4 vapor produced in the process was condensed, and the U determined spectrophotometrically. In the range from 1800 to 2100°C the relative standard deviations for median values of the amount of U leached varied from 4 to 21% for six or more determinations at any given temperature level for a single sample. The amount of U leached was greatly dependent on the temperature, which must be controlled rigorously. It was concluded that the rate-determining step in the leaching process was the diffusion of the U from the core of the bead through the pyrolytic C coating. Author (NSA)

N67-13012*# Ampex Corp., Redwood City, Calif.
THE DYNAMIC BEHAVIOR OF A FOIL IN THE PRESENCE OF A LUBRICATING FILM
A. Eshel and M. Wildmann Sep. 1966 28 p ref
(NASA Order H-76799; Contract Nonr-3815(00)(X))
(NASA-CR-80148; RR-66-29) CFSTI: HC $2.00/MF $0.50 CSCL 20K

Equations for the oscillations of a foil over a lubricating fluid film are derived and are simplified by a small parameter expansion. A few particular cases are discussed, and a linearized solution is obtained for the case of a massless, perfectly flexible foil moving at a speed U over an incompressible film. The solution reveals the phenomenon that small disturbances in the film thickness, as well as symmetrical large disturbances, propagate at a speed U/2. Author

N67-13035# Naval Scientific Technical Information Center, London (England).
THE PROBLEMS OF PITTING IN AUSTENITIC Cr–Ni-STEELS
H. Graefen May 1966 22 p refs Transl. into ENGLISH from Metalloberflaeche (Munich), v. 13, no. 6, Jun. 1959 p 161–166
(NSTIC-TRANS-1305; NSTIC/06780/66; TT-66-62165; AD-638506) CFSTI: HC $1.00/MF $0.50

Investigations were made of corrosion by 'pitting' in various solutions–the effect of redox systems, oxygen and P_H value–construction of potential/time curves and voltage curves–the effect of nitrate additives–electrochemical properties of halogen ions–effects connected with the use of alloys–connection between 'pitting' corrosion and stress cracking corrosion. Author (TAB)

N67-13150# Aeronautical Research Labs., Melbourne (Australia).
THE EFFECT OF MICROSTRESSES ON THE STRESS-CORROSION PROPERTIES OF THE ALUMINUM ALLOY D.T.D. 5044
G. A. Hawkes Nov. 1965 10p refs
(ARL/MET-30) CFSTI: HC $1.00/MF $0.50

Stress-corrosion data have been obtained from specimens cut in the long transverse direction from an aluminum alloy extrusion. The specimens were prepared for test in such a way as to provide examples with approximately zero residual macrostress and increasing levels of microstress. Results from the stress-corrosion tests show that the addition of microstresses arising from cold work has had no effect on the stress-corrosion properties of this alloy. Author

N67-13295# Canada. Dept. of Mines and Tech. Surveys, Ottawa.
EFFECT OF HEAT TREATMENT ON THE CORROSION BEHAVIOR OF TWO ZIRCONIUM-COPPER-MOLYBDENUM ALLOYS
C. F. Dixon and H. M. Skelly Mar. 1966 14p refs
(NP-16239; R-183)

The effect of heat treatment on the corrosion properties of Zr–1.0% Cu–1.5% Mo and Zr–0.5% Cu–0.5% Mo alloys was investigated. The heat treatment found to give optimum corrosion resistance in steam was, for the Zr–1.0% Cu–1.5% Mo alloy, 1000°C for one hr, water quench, followed by aging at 500°C for 32 hr; and, for the Zr–0.5% Cu–0.5% Mo alloy, 1000°C for one hr, water quench, then aging at 500°C for 24 hr. Over-aging of the alloys resulted in growth of the intermetallic-phase particles, which then caused cracking of the corrosion film. Preparation of Zr–3.0% Cu–4.5% Mo alloy, which contained a larger percentage of the intermetallic phase, made it possible to identify, by X-ray diffraction, that phase as being a cubic structure with a unit cell of 4.999 Å. Author (NSA)

N67-13560# Reactor Group, United Kingdom Atomic Energy Authority, Culcheth (England). Reactor Materials Lab.
THE EFFECT OF VARIATION IN PORE SIZE ON THE RATE OF RADIOLYTIC CORROSION OF GRAPHITE BY CARBON DIOXIDE
V. Y. Labaton, B. W. Ashton, and R. Lind 11 Jul. 1966 23 p refs
(TRG-1006(C)) CFSTI: HC $1.00/MF $0.50

The effect of variation in pore size on the rate of radiolytic oxidation of graphite by carbon dioxide has been investigated by oxidation in the DIDO materials testing reactor of 'A' grade graphite to higher weight losses than previously (final open pore volume (O.P.V.) 35 cm^3/100 g at a weight loss of 28%) and also of a range of graphites with varying pore dimensions and open porosity. It has been shown that, if a substantial proportion of the open pores are larger than a critical size, which is dependent on the gas pressure, the oxidation is less than that predicted from its O.P.V., the results being in accord with estimates of initial lengths for recombination collisions of active species. Author

N67-13721 Philips Gloeilampenfabrieken N. V., Eindhoven (Netherlands).
PHILIPS TECHNICAL REVIEW, VOLUME 27, NO. 3/4
S. Gradstein, D. van Dalen, E. Fischmann, J. M. van Hofweegen, J. W. Miltenburg, ed. et al 1966 49 p refs

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N67-13724 Philips Gloeilampenfabrieken N. V., Eindhoven (Netherlands).
GREASE-LUBRICATED SPIRAL GROOVE BEARING FOR A STRAIGHT-THROUGH SHAFT
G. Remmers *In its* Philips Tech. Rev., Vol. 27, No. 3/4 1966 p 107–108 ref (See N67-13721 04-34)

A test motor with grease-lubricated spiral groove bearings capable of taking thrust and radial loads has now been running for 15,000 hours without relubrication. This excellent result encouraged the development of a similar bearing for use with straight-through shafts, which are more often met with in practice. The bearing has a combination of groove patterns on the axial and radial bearing surfaces and also two annular spaces which trap the grease forced out of the bearing, and from which the grease is pumped back to the bearing surfaces. It is expected that this design will in many cases replace the relatively expensive and bulky ball bearings. Author

N67-13953# Atomic Energy of Canada, Ltd., Chalk River (Ontario).
COMPARISON OF WEAR RATES IN WATER FROM DIFFERENT TEST MACHINES
J. T. Dunn Aug. 1966 25 p refs
(AECL-2603) CFSTI: HC $1.00/MF $0.50

Wear rates of different material combinations tested as 1/2-in dia, flat-ended riders reciprocating on a flat surface, were found to be the same, or less than, the wear rates of the same combinations tested as 3/4-in journal bearings. Because of this correlation it appears that the extensive wear results obtained with journal bearing specimens can be used, with a reasonable degree of confidence, to predict the maximum wear of flat sliding surfaces in water. This correlation may not hold for surfaces 1/4-in dia and smaller since the wear of small brass riders on stainless steel is stress dependent at contact stresses over 400 lb/in^2 Author

N67-13971# General Electric Co., San Jose, Calif. Vallecitos Atomic Lab.
STAINLESS STEEL FAILURE INVESTIGATION PROGRAM Quarterly Progress Report, Jan.–Mar. 1966
R. N. Duncan, comp. Apr. 1966 42 p refs Submitted for Publication
(Contract AT(04-3)-189)
(QPR-4; EURAEC-1633; GEAP-5150) CFSTI: HC $2.00/MF $0.50

Corrosion testing of high-purity austenitic alloys with controlled impurity additions in HNO_3+Cr^{+6} indicated that Si is of major importance in determining the intergranular corrosion resistance of austenitic alloys. The C additions also affect the intergranular corrosion resistance but is highly dependent on heat treatment prior to testing. The Mn was shown to have very little effect. Measurements of the anodic polarization characteristics of austenitic tricrystals indicate that the rate of dissolution of the grain boundary is nearly two orders of magnitude higher than the rate of dissolution of the grain centers. Corrosion tests performed in irradiated type-304 stainless steel cladding samples in aqueous $FeCl_2$ at 650°F (0.1 g/l) indicates that irradiation increases the susceptibility of the stainless steel to intergranular attack. Fuel cladding from fuel rods fabricated by co-extrusion showed less susceptibility, in either irradiated or non-irradiated condition, than any other cladding when tested in aqueous $FeCl_2$ at 650°F. A neutron activation analysis technique for chloride in a sample of corrosion product from a reactor was developed. Electrochemical corrosion studies of stainless steel were extended to 300°C. Potentiostatic curves were obtained on various type-304 stainless steel samples. Intergranular attack of stressed type-304 stainless steel samples occurred at 650°F in HCl and NaCl solutions in addition to the $FeCl_2$ solution. Room temperature H_2 embrittlement tests were completed. The tests were inconclusive as to the role H_2 may play in the intergranular failure of type-304 stainless steel fuel rod cladding. Author (NSA)

N67-14062# Southwest Research Inst., San Antonio, Tex. Dept. of Aerospace Propulsion Research.
FUNDAMENTAL INVESTIGATION OF LIQUID–METAL LUBRICATED JOURNAL BEARINGS Quarterly Technical Report, 1 Apr.–1 Jul. 1966
R. A. Burton and Y. C. Hsu 1 Jul. 1966 40 p refs
(Contract AT(11-1)-1228)
(SWRI-1228-8-24; RS-487; QTR-7) CFSTI: HC $2.00/MF $0.50

Numerical techniques, developed in this program for analysis of finite bearings, are shown to apply to both laminar and turbulent films. Comparisons with exact solutions for tilted pads in laminar flows confirm the accuracy of the approach. Data on leading-edge pressure for tilted pads in the large-scale turbulence apparatus are summarized, and shown to yield to correlation in terms of a leading-edge stagnation pressure. When this relationship is applied in tilted pad performance calculations, negative leading-edge pressure is predicted for small tilt angles, and the accompanying center of pressure movement is such as to be associated with instability in pivoted pad applications. Author (NSA)

N67-14105*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ADDITIONS TO FUSED-FLUORIDE LUBRICANT COATINGS FOR REDUCTION OF LOW-TEMPERATURE FRICTION
Katherine M. Olson and Harold E. Sliney Washington, NASA, Jan. 1967 21 p refs
(NASA-TN-D-3793) CFSTI: HC $1.00/MF $0.50 CSCL 11H

Although fused-fluoride solid lubricants exhibit low wear and long lives from 70° to 1500°F (21° to 816°C) in air, at low sliding velocities their friction is high at temperatures from 70° to 900°F (21° to 482°C). An experimental program was conducted to reduce this low-temperature friction by the addition of solid lubricants such as molybdenum disulfide (MoS_2) and silver, which are effective at low temperatures. The friction experiments were conducted in air with a pin-on-disk apparatus. Friction coefficients were measured on each coated disk from 70° to 1200°F (21° to 649°C) or higher and back to 70°F (21°C) where applicable. While MoS_2 additions could be used only once because of their oxidation above 750°F (399°C), they did greatly reduce the friction from 70° to 600°F (21° to 316°C). Better results were obtained if MoS_2 was incorporated into the coating rather than applied over the fused-fluoride coating. Silver was added to calcium fluoride–barium fluoride slurries either as reducible silver halides or as elemental silver powder. The friction coefficients of coatings with 35 weight percent silver powder were 0.2 or less at temperatures from 70° to 1400°F (21° to 760°C), and less than 0.3 during cooling to 70°F (21°C). While

they reduced low-temperature friction, neither MoS_2 nor silver additions adversely affected the wear of the specimens or the life of the fused-fluoride coatings under the conditions of these experiments. Author

N67-14123# Royal Aircraft Establishment, Farnborough (England).
FACTORS AFFECTING THE ENDURANCE OF RUBBED LUBRICANT FILMS OF LAMELLAR SOLIDS
J. P. Giltrow Jun. 1966 17 p refs
(RAE-TR-66184) CFSTI: HC$1.00/MF$0.50

Experiments have been made, using a pin and ring machine, to measure the influence of surface roughness, humidity, and chemical composition on the endurance of rubbed films of lamellar solids. An optimum film life is exhibited on substrates of roughness approximately 30–40 μ in CLA. An environment of high relative humidity during film formation leads to enhanced endurance whilst high humidity during film testing leads to reduced endurance. The coefficients of friction increase with increasing relative humidity of the environment. It is tentatively suggested that the inability of Group VA metal dichalcogenides to lubricate mild and tool steel may be due to their probably non-stoichiometric composition. Author

N67-14326# National Academy of Sciences—National Research Council, Washington, D. C. Materials Advisory Board.
INFORMAL STUDY AND RECOMMENDATIONS REGARDING CORROSION
Aug. 1966 14 p
(Contract DA-49-083-OSA-313)
(MAB-227-M; AD-640055) CFSTI: HC$1.00/MF$0.50

A broad look was taken of the corrosion problem in order to recommend whether or not a deeper study by another committee was needed. There was agreement as to the unsatisfactory manner in which current corrosion problems are usually handled, and regarding the inadequate training of engineers. The formation of a group to provide documentation on a number of specific items, which are listed, was strongly recommended. The topics requiring such study include a summary of the major corrosion problems, our capabilities for attacking corrosion problems, the effectiveness of present methods, and areas ripe for improvement in dealing with corrosion. Author (TAB)

N67-14599*# Sydney Univ. (Australia). Dept. of Medicine.
RHEOLOGY OF SYNOVIAL FLUID AND ITS ROLE IN JOINT LUBRICATION
Leopold Dintenfass *In* N. Y. Med. Coll. Proc. of the 4th Intern. Congr. on Rheol., Pt. 4 1965 p 489–503 refs (See N67-14561 05-04) CFSTI: HC$9.55/MF$2.75

The theories of lubrication were reviewed, and it was concluded that neither the classical hydrodynamic theory nor the boundary theory permits an adequate description and explanation of lubrication in synovial joints. It is suggested that the key factor is the thixotropic behavior of synovial fluid which enables preserving constant load-bearing capacity at various rates of movement. The elastic properties of the articular cartilage might depend on the presence of synovial fluid in its pores. The pressure exerted in the fluid will depend on the elasticity of the cartilage and on the area of contact. The velocity gradient in the gap will depend on the normal and lateral deformations in the articular cartilage. Pathorheology (rheological pathology) of the synovial joints is discussed and related to physicochemical and morphological changes in both synovial fluid and cartilage. The proposed outline of lubrication in synovial joints explains the interdependence of synovial fluid and articular surfaces. Both synovial fluid and articular cartilage are necessary components of joint lubrication. Author

N67-14676# Rock Island Arsenal Lab., Ill. Research and Engineering Div.
INTERFERENCE MICROSCOPIC EXAMINATION OF FLUID FILMS ON METAL SURFACES
Bernard J. Bornong Jun. 1966 36 p refs
(RIA-66-2048; AD-639951) CFSTI: HC$2.00/MF$0.50

Profiles of fluid films on metal surfaces were measured by means of interference microscopy. The purpose of the work was to further characterize the behavior of fluid films and adsorbed films on metals in terms of molecular structure of the fluid components, surface topography and surface energy. The method used was similar to one described by Bascom, Cottington and Singleterry of the Naval Research Laboratory. Film profiles were measured down to thickness of about 1000 angstroms by this method. The results confirmed the mechanism for spreading of liquids which was advanced by Bascom and co-workers. Squalane films containing 0.01% by weight oleic acid did not spread on polished stainless steel or platinum. Films containing 0.01% by weight and 0.3% by weight oleic acid did spread on platinum, but at a slower rate than did the pure squalane. Results are interpreted in terms of known surface energy relationships. Effects of surface contamination by particles and by adsorbed films can be readily observed by the method of interference microscopy. Under some conditions the micro-relief structure of the metal surface can also be observed and estimates made of the heights of the surface elevations. Author (TAB)

N67-14816 Instituto de Pesquisas Tecnologicas, Sao Paulo (Brazil).
HIGH-SILICO IRON CASTINGS, OF HIGH CORROSION RESISTANCE, FOR CHEMICAL PLANTS [FUNDICAO DE PECAS DE FERRO FUNDIDO DE ALTO SILICIO, COM ELEVADA RESISTENCIA A CORROSAO, PARA INDUSTRIAS QUIMICAS]
Cyro Guimaraes and Noriyuki Sugiyama *In* Arg. Comision Nacl. de Energia Atomica 1st Latin Am. Conf. on Process Met. and Metal Working, Vol. I Aug. 1966 46 p refs In PORTUGUESE; ENGLISH summary (See N67-14801 05-17) CFSTI: HC $7.30/MF$2.00

Chemical composition, mechanical and physical properties and corrosion resistance characteristics of high-silicon cast iron are summarized. The experiments carried out at the IPT are described. Studies were concentrated on developing sound casting techniques, degassing of the metal, and heat treatment of the castings to minimize the effects of residual stresses. Author

N67-14958# Naval Research Lab., Washington, D. C.
AN ANNOTATED BIBLIOGRAPHY OF RECENT PAPERS AND REPORTS ON THE SUBJECT OF AMBIENT TEMPERATURE AQUEOUS STRESS-CORROSION CRACKING OF TITANIUM AND TITANIUM ALLOYS
E. P. Dahlberg Oct. 1966 8 p refs
(ARPA Order 878)
(NRL-BIBL-29; AD-642128) CFSTI: HC$3.00/MF$0.65

A listing is presented of sixteen recent papers and reports which deal with stress-corrosion cracking studies of titanium and titanium alloys. The complication is limited to cracking phenomena in aqueous solutions at or near room temperature. A brief summary of the important aspects of each report is included. Author (TAB)

N67-15215*# General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.
MATERIALS FOR POTASSIUM LUBRICATED JOURNAL BEARINGS Quarterly Progress Report, 22 Jan.–22 Apr. 1966
R. G. Frank, ed. 22 Apr. 1966 192 p refs
(Contract NAS3-2534)
(NASA-CR-72041; QPR-12) CFSTI: HC $3.00/MF $1.95 CSCL 13H

The first test assembly on materials for potassium lubricated journal bearings was completed for a test utilizing unlubricated angular contact ball bearings in a wear tester. Potassium flow over the disc specimen was verified visually at 1,000 RPM. Thirty-five friction and wear tests were conducted in the high vacuum friction

and wear tester on several candidate bearing material combinations at RT 400°, 800°, and 1200°F, at pressures of 10^{-9} torr, and at speeds of 800 SFM. Thirty-eight elevated temperature compression tests comprising ten candidate bearing materials were conducted in a vacuum of 10^{-9} torr and at temperatures up to 1600°F. Technical data are included for potassium friction and wear tester arm calibration and specimen testing procedure, as well as for high vacuum friction and wear data. R.Ll.

N67-15216*# General Precision, Inc., Little Falls, N. J. Aerospace Research Center.

RESEARCH ON MATERIALS FOR GAS-LUBRICATED GYRO BEARINGS Technical Summary Report, 1 Dec. 1965–31 Aug. 1966

John L. Rutherford and William B. Swain 31 Oct. 1966 140 p
(Contract NAS12-90)
(NASA-CR-80000; TSR-1) CFSTI: HC $3.00/MF $1.95 CSCL 13H

To develop improved materials for hydrodynamic gyro gas bearings, a comprehensive study of the friction, wear, and dimensional stability characteristics of a selected group of ceramics was undertaken. The materials included: high density Al_2O_3 (Lucalox), cemented Al_2O_3 (Carboloy), hot-pressed Al_2O_3, plasma-arc deposited Al_2O_3 on a Be substrate, and hot-pressed BeO. The surfaces of each material were fully characterized before and after testing. A special test rig for measuring friction and wear properties was constructed. The coefficient of friction and the damage mechanisms and extent were found to be strongly influenced by the surface structure. New, improved machining techniques were developed which enhanced the friction and wear properties. Lubricants were found to be detrimental to these properties. Dimensional changes under zero and applied load were made at extension sensitivities on the order of 10^{-6} inches. Based on these results, Lucalox, Carboloy and plasma-arc deposited Al_2O_3 are most promising for gyro gas bearing applications.
Author

N67-15217*# General Electric Co., Cincinnati, Ohio. Research and Development Center.

HYDRODYNAMIC JOURNAL BEARING PROGRAM Quarterly Progress Report, 29 Oct. 1965–29 Jan. 1966

J. D. McHugh, H. E. Nichols, and W. D. C. Richards 18 Apr. 1966 127 p refs
(Contract NAS3-6479)
(NASA-CR-72034; QPR-3) CFSTI: HC $3.00/MF $1.95 CSCL 13I

The results of the dynamic evaluation testing of proximity probes (when provided with a teflon cap to shield against water) are presented. Also, the results of the dynamic loader bearing friction torque calibration are included. In addition, the force gauges which support the test bearings have been calibrated on a special test rig operated to 7000 rpm. Manufacture of the main test rig for this program has been completed and all parts received. Design of a self-aligning pivoted pad bearing is in progress. A critical speed analysis of the test rig for test-planning purposes has been completed. Author

N67-15255*# Vitro Labs., West Orange, N. J.

ELECTROPHORETIC DEPOSITION OF METAL-BONDED MOLYBDENUM DISULFIDE FOR GEAR LUBRICATION Final Report, 17 Jun. 1965–31 May 1966

31 May 1966 48 p refs
(Contract NAS5-9623)
(NASA-CR-81133) CFSTI: HC $3.00/MF $0.65 CSCL 13H

The electrophoretic deposition technique was adapted to the coating of Type 303 stainless steel test pins, test discs, and worm gears with codeposited solid lubricant films containing 20 volume % MoS_2 plus Monel or silver–copper eutectic. In Falex tests, the silver–copper bonded film exhibited better adherence than the Monel bonded composition and sustained loads of up to 140 lbs. with a coefficient of friction of 0.05 or less when run against uncoated C1137 steel "V" blocks (20–25 Rc) at 290 rpm. In pin and disc sliding friction tests, the best of the Ag–Cu bonded coatings maintained a coefficient of friction of less than 0.3 for 60 hours when rubbed against an uncoated bronze sphere at a normal load of 60 grams and a speed of 4 fpm. The best of the Monel bonded films ran a total of 96 hours with a coefficient of less than 0.3 under the same load and at a speed of 40 fpm. Both films wore rapidly when the normal load was increased to 600 grams. A set of 16 single thread, right hand, 0.3333 in pitch diameter, Type 303 stainless worm gears were coated with each of the lubricant films. Author

N67-15292# Rock Island Arsenal Lab., Ill. Research and Engineering Div.

REACTIONS OF POTENTIALLY SUITABLE VCI COMPOUNDS WITH NONFERROUS METALS

Peter Martin, Jr. Jul. 1966 20 p refs
(RIA-66-2246; AD-639949) CFSTI: HC $1.00/MF $0.50

Restrictions currently exist in the use of volatile corrosion inhibitors (VCI) because of the adverse effects on some nonferrous metals and nonmetals. Work was initiated to develop VCIs which would be inert or passive to both nonferrous metals and nonmetals but still have the ability to vaporize to combat a corrosive environment. Possible VCI compounds were selected and their vapor pressures were measured by the Torsion-Effusion method. Vapor pressure data was obtained for amines of the nitrites, carbonates, benzoates, chromates and caprylate at 21 C. Values ranged from <0.00001 to 0.0048 mm of Hg. Vapor pressure-temperature curves were determined for benzylamine carbonate and dicyclohexylamine caprylate. Reactivity tests were conducted showing the nature and intensity of the attack of the VCI compounds on nonferrous metals. The test consisted of exposing Cu, Cd, Mg, Zn and Al specimens to the VCI compounds for 7 days at 150 F. in the presence of high humidity. Weight loss measurements were used to evaluate the attack on the metals in mils penetration per year (mpy). On the basis of the results obtained the following conclusions were made. (a) Cadmium and magnesium are more severely attacked by the VCI compounds in the presence of water vapor than the other metals tested, (b) there is not one of the VCI compounds which decreases the corrosion rate of all the metals tested or which has the least corrosive effect and (c) no correlation was found between the vapor pressures and the reactivity with nonferrous metals. Author (TAB)

N67-15310# Massachusetts Inst. of Tech., Cambridge. Surface Lab.

SURFACE ENERGY EFFECTS IN SLIDING PHENOMENA Final Report, 1 Jul. 1963–30 Jun. 1966

Ernest Rabinowicz 12 Sep. 1966 96 p refs
(Contract DA-31-124-ARO(D)-143)
(AROD-4266.4; AD-640180) CFSTI: HC $3.00/MF $0.75

It has been proposed that surface energy manifests itself in a sliding system through a characteristic distance, equal to the size of wear particles for that system. This hypothesis was tested in systems in which other distance parameters were introduced, namely abrasive particles of varying sizes, solid films of varying thickness, and sliding surfaces of varying roughness. A minimum load was postulated below which low wear rates would prevail, and a number of experiments were carried out to test this prediction. The effect of material compatibility on friction and wear were evaluated. The experimental results either agreed with the predictions of the surface energy model, or at any rate were not inconsistent with them. Author (TAB)

N67-15315# Boeing Scientific Research Labs., Seattle, Wash. Solid State Physics Lab.

STRESS CORROSION CRACKING OF TITANIUM ALLOYS. PRELIMINARY REPORT ON Ti:8Al–1Mo–1V ALLOY AND PROPOSED ELECTROCHEMICAL MECHANISM

T. R. Beck Jul. 1966 111 p refs
(D1-82-0554; AD-640229) CFSTI: HC $4.00/MF $0.75

Stress corrosion cracking of titanium: 8% Al - 1% Mo 1% V alloy specimens was investigated in various salt solutions at controlled potentials applied by a potentiostat. Polarization curves on titanium oxide surfaces and kinetic data for oxidation of newly formed titanium alloy surface were also obtained. It was found that stress corrosion cracking of duplex annealed Ti:8-1-1 alloy occurred in chloride, bromide, and iodide solutions but did not occur in other solutions such as fluoride, hydroxide, sulfide, sulfate, nitrate or perchlorate. The ultimate strength was strongly dependent upon potential. The velocity of crack propagation and current flowing into the crack in chloride, bromide and iodide solutions were linearly related to the applied potential above a potential of -900 mv to the saturated colomel electrode. An electrochemical model was developed to interpret the data. Anodic reaction with the halides is considered to initiate at the -900 mv potential and the rate of crack propagation to be limited by the potential drop through the electrolyte in the crack. It is planned to extend the investigation to other alloys using the model as a guide for the design of experiments. Author (TAB)

N67-15393# Joint Publications Research Service, Washington, D. C.

PIERCING WITH FORCED FEED OF BILLET

Ya. S. Finkel'shteyn *In its* Seamless Tube Production 30 Dec. 1966 p 1–25 refs (See N67-15392 06-15)

Equations are developed for analyzing the conditions of force equilibrium in the deformation zone, taking into account the direction of friction forces. The process kinematics are evaluated from an analysis of the axial slip factor. A method is suggested for studying the dynamics of the piercing process, and the force feed conditions, and power and roll power are determined. Coefficients characterizing the force and energy conditions of piercing with forced feed are proposed and discussed. N.E.N.

N67-15502 Instituto de Pesquisas Technologicas, Sao Paulo (Brazil).

SOME PROBLEMS RELATED TO THE CORROSION OF METALS [ALGUNS PROBLEMAS DE CORROSAO DE METAIS]

Stephan Wolynec and Idel Metzger *In* Arg. Comision Nacl. de Energia Atomica 1st Latin Am. Conf. on Process Met. and Metal Working, Vol. II Aug. 1966 52 p refs In PORTUGUESE; ENGLISH summary Presented at the Brazilian Metal Assoc. 19th Ann. Congr., Sao Paulo, Jul. 1964 (See N67-15501 06-17) CFSTI: HC $3.00/MF $0.65

For increased industrial safety and equipment efficiency, a theoretical analysis of corrosion mechanisms is presented. Various types and causes of corrosion are identified, and chemical analysis or metallographic test procedures described. The following mechanisms are involved: stray current corrosion of underground piping, stress corrosion of concrete reinforcements, crevice corrosion of stainless steel sheets, and intergranular corrosion due to carbide precipitation in stainless steel tubing. An extensive bibliography is included. Transl. by R.LI.

N67-15780# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

INVESTIGATION OF THE ANTIWEAR PROPERTIES OF REACTIVE FUELS

A. P. Gryaznov and I. V. Rozhkov 12 Apr. 1966 11 p refs Transl. into ENGLISH from Khim. i Tekhnol. Topliv i Masel (Moscow), no. 4, 1964 p 57–60
(FTD-TT-65-1730; TT-66-62518; AD-641107) CFSTI: HC $3.00/MF $0.65

A procedure was developed which permits the evaluation of the properties of reactive fuels on a setup with fuel equipment used on a full-sized turbojet engine. In agreement with results obtained earlier, it was shown that of the standard reactive fuels, the highest antiwear qualities are had by the fuels T-5 and T-1, the lowest by the fuel T-2, the fuel TS-1 occupying a middle position. With the raising of the temperature of the fuel within the limits of from 60 to 150C, the wear of the frictional surfaces considerably increases. The addition to the fuel TS-1 of 0.01 - 0.02% of additives ionol (2,6-di-t-butyl-4-methylphenol) and V-15/2A (an organosulfur compound), which possess surface-active properties, makes it possible to improve the antiwear properties of the fuels. With the test of the fuel TS-1 with the additive ionol at temperatures higher than 100C there was noted the formation of deposits on the fuel equipment. Author (TAB)

N67-16042*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STUDIES OF LOW AND HIGH TEMPERATURE CAGE MATERIALS

E. V. Zaretsky, H. W. Scibbe, and D. E. Brewe Washington, NASA, 1967 31 p refs To be presented at the Spring Lubrication Conf., Miami Beach, Fla., 5–7 Jun. 1967; Sponsored by ASME
(NASA-TM-X-52262) CFSTI: HC $3.00/MF $0.65 CSCL 13H

Seven self-lubricating retainer materials were evaluated in 40-millimeter-bore ball bearings operating in a 60° R hydrogen gas at 20,000 rpm and with a 200-pound thrust load. The relative wear of six high-temperature bearing cage materials was also determined at 500° and 700° F in a nitrogen-blanketed cage compatibility tester. When used as cages, glass-fiber-filled and bronze-filled polytetrafluoroethylene (PTFE) materials provided transfer films on the bearing inner-races for test durations exceeding 10 hours without evidence of race wear at the cryogenic temperature. Minimum cage wear was obtained at cryogenic temperature with the laminated-glass cloth PTFE and the filled PTFE materials. At the elevated temperatures, S-Monel and AISI M-1 materials gave least wear. For these materials wear decreased with increasing material hardness. Author

N67-16048*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE EFFECT OF THE SPACE ENVIRONMENT ON LUBRICANTS AND ROLLING ELEMENT BEARINGS

W. J. Anderson and D. C. Glenn Washington, NASA, 1967 48 p refs To be presented at the Conf. on Lubrication and Wear—Fundamentals and Appl. to Design, London, 25–28 Sep. 1967; Sponsored by Inst. of Mech. Engr.
(NASA-TM-X-52268) CFSTI: HC $3.00/MF $0.65 CSCL 13I

The effects of spatial environmental factors such as the very low ambient pressure and the absence of oxygen on lubrication are discussed. The low pressure causes liquids, and even solids, to boil away so that their vapor pressure and evaporation rates become important. Evaporation experiments with metals, liquids, greases and solid lubricants are discussed. Silicone oils and silicone based greases appear to have the lowest evaporative loss among the fluids investigated. Bearing experiments indicate that liquids and greases, when properly shielded, can provide longer bearing lives than bonded solid lubricants or metal platings. Silicone fluids yield the best bearing life, confirming the results of evaporation tests. Life results with bonded solid films are generally poor. Results are considerably better when the solid lubricant is used as a constituent in a solid-composite material. Bearing reliability in space applications may be a problem because considerable life scatter is observed where a particular lubricant or lubrication technique is evaluated in multiple tests. Life ratios of 10 were common. Author

N67-16409# Marine Engineering Lab., Annapolis, Md.

HOT CORROSION IN MARINE GAS TURBINE

G. J. Danek, Jr. Oct. 1966 23 p refs
(MEL-392/66; AD-640736) CFSTI: HC $3.00/MF $0.65

The phenomenon of hot corrosion in marine gas turbines is stimulated by the presence of sodium sulfate. Two avenues can be followed to minimize deterioration by hot corrosion: (1) control of environmental conditions to prevent the formation of a molten

slag and (2) development of materials to resist corrosive attack. Several techniques have been proposed to curtail the formation of a fused slag: limiting the gas turbine operating temperature which, though effective, seriously limits efficiency and fuel economy (present method); eliminating sea salt from the combustion zone by filtering to avoid formation of the aggressive environment; and other promising techniques for controlling environmental conditions such as blade cooling and fuel additives. The development of materials with built-in hot corrosion resistance would provide the most desirable solution to the problem. Therefore, considerable effort is being expended to devise tailor-made coatings and alloys. Supporting the development efforts are mechanism studies which are aimed at understanding of the interactions between the marine gas turbine environment and hot section materials, and identifying beneficial alloying constituents. Experience so far indicates that none of the specific approaches alone will provide a complete solution to the problem. Author (TAB)

N67-16456# Naval Air Engineering Center, Philadelphia, Pa.
EVALUATION OF ENVIRONMENTAL PROTECTION AFFORDED TO SYSTEM STOCKS OF ANTI-FRICTION BEARINGS
E. J. Lion 17 Nov. 1966 35 p
(NAEC-AML-2447; AD-643354) CFSTI: HC $3.00/MF $0.65

Laboratory examinations were conducted to evaluate the condition of stock bearings received from various field installations. The preservation, packaging and packing of each bearing was evaluated with each component of the pack being examined for signs of deterioration. Author (TAB)

N67-16592# Naval Ordnance Lab., White Oak, Md.
PROTECTIVE COATINGS FOR MAGNESIUM
John R. Aldridge 14 Sep. 1966 45 p refs
(NOLTR-66-110; AD-641177) CFSTI: HC $3.00/MF $0.65

Following a survey of military specifications, several coatings were tested for the Signal, Smoke and Illumination, Submarine, Ex 85, Mod O, which is made of magnesium. The best materials were subjected to salt spray tests. Results show alkaline resistant coatings of 2.0 to 4.0 mils, such as epoxies, polyurethanes and vinyls, are satisfactory over suitable pretreatments. Author (TAB)

N67-16693*# *National Aeronautics and Space Administration.* Lewis Research Center, Cleveland, Ohio.
EVALUATION OF HIGH-TEMPERATURE BEARING CAGE MATERIALS
Erwin V. Zaretsky and William J. Anderson Washington, NASA, Jan. 1967 21 p refs
(NASA-TN-D-3821) CFSTI: HC $3.00/MF $0.65 CSCL 13I

A cage compatibility tester was used to determine the relative wear characteristics of six cage materials with four lubricants of practical interest. Test conditions were ambient temperatures of 500° and 700°F, a shaft speed of 1200 rpm, and test durations of from 30 to 120 minutes. Measurements of the wear scar in the cage pocket were used to determine the effect of cage material, temperature, lubricant, and material hardness on cage wear. For the temperature range of 500° to 700°F, S-Monel and M-1 materials gave the least wear. Additionally, at 500°F, 440°C (modified) steel and a polyimide polymer indicated low wear. The best results in terms of low wear were obtained at 500°F with an M-1 material of Rockwell A hardness 81 run with an ester-base lubricant. At 700°F, minimum cage wear was obtained with a polyphenyl ether lubricant and S-Monel material of Rockwell A hardness 67. For a given cage material, cage wear decreased with increased material hardness. This result suggests that cages for high-temperature application should be heat treated to their maximum practical hardness. Author

N67-16886# Mechanical Technology, Inc., Latham, N. Y.
PROCESS FLUID LUBRICATION Final Technical Report
D. E. Dougherty and C. H. T. Pan Sep. 1966 15 p refs
(Contract Nonr-3731(00) (FBM))
(MTI-66TR50; AD-641369) CFSTI: HC $3.00/MF $0.65

The research program in process fluid lubrication is divided into four functional study tasks: (A) Steam lubrication, (B) Low kinematic viscosity fluids, (C) Materials evaluation for water and steam bearings, and (D) Related analytical studies. TAB

N67-16919*# Santa Clara Univ., Calif.
CONICAL PIVOT BEARINGS FOR SPACE APPLICATIONS
George G. Herzl *In its* Aerospace Mech. 20 May 1966 p 203–222 refs (See N67-16901 07-30) CFSTI: HC $3.00/MF $0.65

Conical pivot bearing characteristics and performance are analyzed, and criteria for minimal torque design are presented. In the analysis, the fundamental considerations for determining contact pressure between pivot and bearing are identified as the position of the pivot (i.e., horizontal or vertical in analogy to terrestrial applications), and the location of the contact between pivot and bearing (i.e., in the spherical bearing region or on the sloping sides) The crucial part of the design analysis, with respect to minimal friction characteristics, is considered to be the determination of the smallest possible pivot tip radius consistent with the requirement that under all possible operating conditions the tip material will undergo only elastic, and not permanent, deformation. Formulas for calculating optimum bearing dimensions are also derived. It is concluded that conical pivot bearings offer a simple technique for achieving a predictable alignment within a small space and for providing extremely low friction. M.G.J.

N67-16965# Air Force Systems Command, Wright-Patterson AFB, Ohio. Systems Engineering Group.
APPLICATION OF NUCLEONIC MASS MEASUREMENT TECHNIQUES FOR MEASUREMENT OF TWO-PHASE FLUID CONDITIONS EXISTING IN AIRCRAFT FLUID SYSTEMS
Harry W. Schmidt *In* AEDC Proc. of the 13th Ann. AF Sci. and Eng. Symp., Vol. II 1966 28 p refs (See N67-16962 07-34) CFSTI: HC $3.00/MF $0.65

An investigation of various measurement techniques revealed the potentiality of utilizing nucleonic mass measurement techniques for aeration detection in the T-34 lubrication system. Descriptions of the principles of radiation attentuation of radiation in matter, detection techniques, and system accuracy are given. In-house testing efforts proved the validity of the measurement technique, but proved the available hardware inadequate for actual flight test aeration measurements. A basic description of the nucleonic equipment and the test results are discussed. The development goals and applications of the across-the-board type nucleonic instrument are described. Anticipated benefits that nucleonic mass measurement technique will have on future design and testing of aircraft fluid flow systems are described and include specification updating as a result of the increased knowledge of fluid flow characteristics, and improved assurance that new aircraft designs will meet oil aeration and fuel V/L (vapor–liquid ratio by volume) specification requirements. Author

N67-17089 General Dynamics/Convair, San Diego, Calif.
THE SUSCEPTIBILITY OF K-MONEL TO HYDROGEN EMBRITTLEMENT
R. W. Tryon and J. B. Steinman Jan. 1966 20 p refs
(ZZL-65-027; AR-572-1-572)

A test program was performed to determine the susceptibility of K-Monel to hydrogen embrittlement. Tensile, notched tensile, and bend properties were determined on "as received" and on "charged" K-Monel test specimens. The test data indicated little effect on the tensile and notched tensile properties of K-Monel in either the annealed or aged conditions as a result of cathodically, hydrogen charging in a salt water environment. However, a significant decrease in the bend ductility of aged K-Monel resulted from hydrogen charging. Limited tests on Type 301 stainless and 4340 steels were performed for comparison. It is concluded from

this program that 4340 and 301 steels are definitely susceptible and that K-Monel, under certain conditions, is susceptible to hydrogen embrittlement. Author

N67-17663# Pennsylvania Univ., Philadelphia. Electrochemistry Lab.
HYDROGEN EMBRITTLEMENT RESULTING FROM CORROSION, CATHODIC PROTECTION, AND ELECTROPLATING Final Report, 14 May 1965–May 1965–13 May 1966
E. Gileadi Sep. 1966 36 p refs
(Contract N156-46659)
(AD-641089) CFSTI: HC $3.00/MF $0.65

A technique was developed and the apparatus built for a fast, nondestructive method for the determination of hydrogen content of large specimen. Also, a study of the basic factors which determine the solubility and the rate of diffusion of hydrogen in metals was undertaken. The approach was to change systematically the metallurgical and physical properties of iron by forming binary alloys of variable composition, and to study the resulting changes in hydrogen diffusion rate and solubility. TAB

N67-17670# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
PROTECTION OF METALS WITH RUBBER COATINGS AGAINST CAVITATIONAL WEAR
V. M. Konovalov and K. Shabalin 7 Oct. 1966 10 p refs Transl. into ENGLISH from Izv. Vyssh. Ucheb. Zaved., Mashinostro. (Moscow), no. 9, 1965 p 86–89
(FTD-HT-66-510; AD-643734) CFSTI: HC $3.00/MF $0.65

The protective ability of rubber coatings against cavitational wear was investigated by two methods: movable and stationary sample. The tests showed that soft rubber coatings provide the best protection. Soft rubber coatings are especially effective in the protection of details, the natural movement and vibration of which in a liquid cause their cavitational wear. TAB

N67-17685# Oak Ridge National Lab., Tenn. Reactor Chemistry Div.
CORROSION OF CARBON AND ALLOY STEELS IN WATER AND SEAWATER
S. A. Reed Oct. 1966 20 p refs
(Contract W-7405-ENG-26)
(ORNL-TM-1612) CFSTI: HC $3.00/MF $0.65

Current knowledge of the factors that govern the corrosion and the service life of steel in sea water evaporation environments is summarized. Some data from OSW research and development reports are included. It is concluded that information currently available is inadequate to provide any reliable estimate of the life expectancy of carbon steel in sea water evaporator environments. Additional testing is necessary at lower dissolved oxygen levels to determine more precisely the role of oxygen in the corrosion of steel in hot sea water and brine. (25 references). NSA

N67-17697# Oak Ridge National Lab., Tenn. Reactor Chemistry Div.
DYNAMIC CORROSION FOR THE HIGH FLUX ISOTOPE REACTOR
J. L. English and J. C. Griess Sep. 1966 43 p refs
(Contract W-7405-ENG-26)
(ORNL-TM-1030) CFSTI: HC $3.00/MF $0.65

The results of a testing program to examine the long-term corrosion behavior of materials of interest to the High Flux Isotope Reactor (HFIR) are presented, and their significance to the operation of the HFIR is discussed. The test environment was water, adjusted to a pH of 5.0 with HNO_3, at 100°C and at flow rates ranging from 0.5 fpm to 81 fps. Under all flow conditions, the Al alloys corroded at low rates, 0.2 mpy at the higher velocities and less than 0.1 mpy at the lowest velocities. Contacting Al with Al, Be, Ni, types 304, 416, 420, or 17-4PH stainless steel resulted in pitting of the Al in the contact areas only. While of appreciable depth, the pits were randomly spread and should not be of major consequences in the HFIR system. Be, both by itself and in contact with other metals, was subject to light pitting attack. Pits did not exceed 13 mils in depth in tests that lasted in excess of one year. Within the velocity range of 13 to 81 fps, the average corrosion rate of Be was independent of velocity and constant at 2 mpy. One specimen of Be in contact with type 304 stainless steel developed evidence of stress-corrosion cracking. Commercial-grade Ni underwent shallow pitting attack and corroded at an average rate of 2 mpy. An electroless Ni deposite on 6061 Al corroded at the high rate of 19 mpy. Electrolyzed coatings (a proprietary process for coating materials with Cr) on stainless steel exhibited excellent corrosion resistance and good adherence to the stainless steel. Similar deposits flaked and peeled from Al surfaces. Hardened type 416 stainless steel was subject to blistering while type 420 stainless steel underwent stress-corrosion cracking. Delrin, a polyformaldehyde plastic considered as a gasket material, suffered near-complete degradation after a short time in test. NSA

N67-17734# Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant.
OIL RECLAMATION USING MOLECULAR SIEVES
R. DeMonbrun, I. G. Speas, and W. E. Weathersby 29 Sep. 1966 60 p refs
(Contract W-7405-ENG-26)
(Y-1552) CFSTI: HC $3.00/MF $0.65

A study was made of the reuse of various types of organic oils and tri-aryl phosphate ester fluids used in large volume at the Oak Ridge Y-12 Plant. It was concluded that molecular sieve desiccant affords an economical means of obtaining highly purified stocks for reuse. A simple regenerative equipment arrangement has proved to be suitable for the purification of a wide range of lubricating, hydraulic, and insulating fluids. Author (NSA)

N67-17751# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
WEAR RESISTANCE OF ALLOYS FOR GAS TURBINE INSTALLATIONS
A. I. Lavysh and M. G. Morozov 7 Oct. 1966 11p refs Transl. into ENGLISH from Izv. Vysshikh Uchevn. Zavedenii, Energ. (Minsk), no. 9, 1965 p 115–119
(FTD-HT-66-511; TT-67-60233; AD-643876) CFSTI: HC $3.00/MF $0.65

The problem of structural materials for gas turbine installations has been satisfactorily solved by the level of their heat resistance and it was perfectly and entirely uncovered with respect to wear resistance. TAB

N67-17831*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LUBRICATION AND WEAR FUNDAMENTALS FOR HIGH VACUUM APPLICATIONS
Robert L. Johnson and Donald H. Buckley Washington, NASA, 1967 42 p refs To be Presented at the Conf. on Lubrication and Wear Fundamentals and Appl. to Design, London, 25–28 Sep. 1967; Sponsored by Inst. of Mech. Engr.
(NASA-TM-X-52271) CFSTI: HC $3.00/MF $0.65 CSCL 11H

Summarized are basic observations of lubrication related phenomena in the vacuum environment. Included are data on vacuum technology, formation and degradation of lubricating films, cleavage studies of lubricating materials, adhesion of clean materials, and friction and wear phenomena. S.C.W.

N67-17938# General Dynamics/Convair, San Diego, Calif.
METALLURGICAL INVESTIGATION AND MECHANICAL PROPERTIES OF SPOT WELDED JOINTS CONTAINING CORROSION DEFECTS IN A CENTAUR AFT BULKHEAD-TANK 1D
Charles J. Kropp [1966] 36 p refs
(ZZL-66-008; AR-572-1-598)

Radiographs of the weld joints in the aft bulkhead of a scrapped Centaur tank (1D) were examined and several spot welds were cross-sectioned to determine the extent of the corrosion which was detected on the X-ray film. The results of this metallographic examination correlate very well with the results of a similar previous investigation. Other sections of weld joints from this bulkhead were then fabricated into test specimens and subjected to both a sustained load test and an ultimate tensile test at −320°F. As a result of the weld joint tests conducted and presented in this report, some information is made available concerning the effects that corrosion defects, present in the weld joints, may have on the mechanical properties of the joints when compared to defect-free joints. Author

N67-18154*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.

STRESS-CORROSION CRACKING OF Ti–6Al–4V ALLOY IN METHANOL

Robert L. Johnston, Robert E. Johnson, Glenn M. Ecord, and Willard L. Castner Washington, NASA, Feb. 1967 20 p
(NASA-TN-D-3868) CFSTI: HC$3.00/MF$0.65 CSCL 11F

Results of an investigation to determine if an incompatibility exists between methanol and Ti–6Al–4V solution-treated and aged alloy are presented. The test specimens were obtained from virgin solution-treated-and-aged sheet material and from the remnants of two Apollo service propulsion system fuel tanks which failed while containing methanol under pressure. The investigation shows that methanol and stressed Ti–6Al–4V alloy are incompatible and result in tank failure because of a stress-corrosion mechanism. Author

N67-18290# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

UTILIZING WASTES OF THE SYNTHETIC RUBBER INDUSTRY IN THE ROLE OF ACID CORROSION DECELERATORS

V. A. Khitrov, V. P. Zadorozhniy et al 30 Mar. 1966 12 p refs Transl. into ENGLISH from Khim. Prom. (Leningrad), no. 4, 1964 p 307–310
(FTD-TT-65-1626; TT-66-62519; AD-641108) CFSTI: HC $3.00/MF$0.65

When manufacturing divinyl by catalytic decomposition of ethyl alcohol, synthetic rubber plants are using various wastes of complex composition, which can serve as decelerators of acid corrosion of certain metals. To these wastes belong so called 'foamy reagent' (an alcohol–hydrocarbon mixture), vat remains (low B.P. hydrocarbons), and motor fuel (non-polymerized hydrocarbons). The effectiveness of these wastes in retarding corrosion in the following systems is reported: low carbon steel 08 in 1 and 7 percent solutions of sulfuric and hydrochloric acid solutions; stainless steel 1KH18N9T in 1 and 7 percent of hydrochloric acid; copper in 3 percent nitric acid. TAB

N67-18476# Centre National de la Recherche Scientifique, Paris (France).

[PREPARATION AND PROPERTIES OF STAINLESS STEELS] Quarterly Report, 1 Apr.–30 Jun. 1966

G. Chaudron 30 Jun. 1966 21 p
(Contract EURATOM-059-65-7 TEEF (RD))
(EUR-2868; EURAEC-1678; QR-14) CFSTI: HC$3.00/MF$0.65

The effects of C concentration on the properties of austenitic stainless steels of 18-10 type were studied. Alloys with 18% Cr, 12% Ni, and various C contents were prepared. The steels involved are respectively a, steel containing 20 ppM C, b, steel with 80 ppM C, and c steel with 600 ppM C. The mechanical properties of these alloys were determined by measuring the Vickers hardness as well as by recording the tensile curves for wires; the presence of C causes an increase of the elastic limit and the ultimate tensile strength of the steels. The effects of C on the corrosion of austenitic stainless steels were investigated. Particular attention was directed toward corrosion by pitting in ferric chloride; intergranular corrosion by dechromization, revealed by $CuSO_4$ reagent; and intergranular corrosion in boiling HNO_3 with addition of hexavalent Cr. NSA

N67-18523# Centre d'Etude de l'Energie Nucleaire, Mol (Belgium).

IMPERFECTIONS IN METALS. II: CORROSION AND OXIDATION

31 Mar. 1966 14 p refs
(Contract EURATOM-054-64-4 TEEB)
(EURAEC-1701; EUR-2889; R-2384; QR-14) CFSTI: HC $3.00/MF$0.65

The defect structure caused by mechanical working of stainless steel surfaces was investigated by electron microscopy in transmission. A high density of dislocations was observed which is in agreement with the model proposed elsewhere for the enhanced corrosion resistance caused by such treatments. The precipitation at the grain boundaries of chromium carbides in steel type AISI 304 was studied by the same technique. The precipitation treatments were performed either during the observation in the electron microscope or in a furnace. It was found that no defect structure, caused by the precipitation, is visible near the grain boundaries. A similar mechanism as was proposed for the mechanically deformed surfaces cannot account for the zones of improved corrosion resistance along the grain boundaries. Author (NSA)

N67-18601# Laboratoires du Centre d'Etude de l'Energie Nucleaire, Mol (Belgium).

IN-PILE CORROSION OF NUCLEAR MATERIALS Quarterly Report No. 4, Dec. 1, 1965–Feb. 28, 1966

28 Feb. 1966 19 p
(Contract EURATOM-055-65-3 TEEB (RD))
(EURAEC-1702; EUR-2888; R-2388) CFSTI: HC$3.00/MF$0.65

In order to determine the effects of radiolysis of water on the electrochemical potential of steel and Pt, the potential changes of these metals have been measured in solutions containing ferrous and ceric ions. It has been found that the potential of Pt in a solution of Fe^{3+} and Ce^{4+}/Ce^{3+} by gamma irradiation may show a drop of about 700 mV indicating reduction of the ceric ions. Steel in the same solution sometimes also indicates a potential decrease by gamma irradiation of the solutions. However, the results are obscured by the ability of steel to reduce excess ceric ions. A potential rise in solutions of $Ce^{3+}+Fe^{3+}/Fe^{2+}$ has not been found during the applied irradiation times (65 hours at 1.68×10^5 RAD/hr). Addition of an organic impurity to the water (ethyl alcohol) further decreases the electrochemical potential of Pt. The Pt potential in that case corresponded to that of the hydrogen electrode. It was again not definite whether alcohol addition affected the potential of steel. The potential drops observed were less pronounced than in the case of Pt. Analysis of the solution and the oxide on 18/8 stainless steel and the H_2SO_4 solution used for coulometric reduction of the oxide has shown that chromium oxide may dissolve. Potential-time curves measured during reduction of oxide films on pure chromium showed two distinctive steps in the reduction process. Author (NSA)

N67-19080# National Research Council of Canada, Ottawa (Ontario). Fuels and Lubricants Lab.

COMPARATIVE LABORATORY PERFORMANCE OF AIR BRAKE CYLINDER LUBRICANTS

L. D. New and B. I. Patterson Aug. 1966 15 p ref
(NRC-9296; MP-43) CFSTI: HC$3.00/MF$0.65

A test method for measuring the low temperature release time and the high temperature cup wear preventive properties of air brake cylinder lubricants is described. The results of comparative trials of reference and various proprietary lubricants are given. A non-soap thickened polyglycol grease containing MoS_2 was best at 150°F, and proprietary products gave acceptable performance at both temperature levels. The relationship between composition and performance of the air brake cylinder lubricants tested is noted. Author

N67-19116*# Aluminum Co. of America, New Kensington, Pa. Alcoa Research Labs.
DEVELOPMENT OF IMPROVED CONVERSION COATINGS FOR ALUMINUM ALLOYS Final Report, 1 May 1964–31 Jul. 1966
W. G. Zelley 14 Sep. 1966 248 p
(Contract NAS8-11226)
(NASA-CR-82660) CFSTI: HC $3.00/MF $0.65 CSCL 11F

An investigation was conducted on the protection of 2219 alloy by chemical conversion coating techniques, with reference to space vehicle components. The corrosion properties of the alloy in various tempers were considered, and the Iridite 14-2 process, now in use, was studied. Other conversion coatings, with and without chromate, were considered. Surface preparatory treatments were investigated, and the advantage of a mechanical finish for producing an effective coating was shown. Electrochemical assists, double coating, and sealing were evaluated. The value of reducing Iridite solution pH or increasing the concentration was demonstrated, and a 10 oz/gal. solution was studied in depth. Production operational problems were considered, including a pilot plant scale test. Salt spray, humidity, and atmospheric exposure tests were conducted on 2219 alloy in various tempers and on other representative aluminum alloys. The exposure and alloy factors affecting results are discussed. Although the objective of a completely protective coating on 2219-T87 alloy in a 168 hours salt spray exposure was not attained, recommendations were made for the optimum processing of this material according to the data accumulated. Author

N67-19347# Oak Ridge National Lab., Tenn.
ELECTROCHEMICAL KINETICS AND ITS APPLICATION TO CORROSION
In its Chem. Div. Sep. 1966 p 88–94 refs (See N67-19341 08-06) CFSTI: HC $3.00/MF $0.65

Further studies on the inhibition of corrosion of iron and steel showed that inorganic substances of the general formula $(O_4$ exert a noncathodic effect that greatly facilitates the passivation process. A mechanism is proposed, which accounts for the complex electrochemical behavior of iron in the presence of adsorbed anionic inhibitors. Studies with a rotating disk electrode assembly on the dissolution of Zr in HF–HCl and HF–HNO_3 mixtures showed that at potentials below the pitting potential in chloride media the rates of dissolution in the two solutions are identical. Other experiments in HF–H_3PO_4 solutions disclosed a reduction in dissolution rate by several orders of magnitude; PO_4 ion inhibited the dissolution reaction by HF in a manner similar to the SO_4 ion. The rate of the anodic dissolution reaction of aluminum in alkaline NaCl solutions was measured as a function of pH, electrode potential, and time by use of a rotating disk electrode assembly. Experiments were initiated on electrochemical aspects of the formation and growth of pits on titanium in chloride solutions. Polarization curves of Ti and some of its alloys were measured in chloride solutions at temperatures up to 200°C by use of a Ti loop facility equipped for electrochemical studies. In the presence of a sufficient quantity of chloride ions, Ti alloys exhibited a pitting potential, which in some cases is low enough to allow pitting attack to proceed spontaneously. Electrochemical aspects of the corrosion of types 5454 and 6061 Al alloys were studied in 1M NaCl at 150°C in Ti loop facilities. Changes in the polarization curves of anodic and cathodic processes occurring at the Al–electrolyte interface with pH provided a kinetic explanation for the existence of a minimum corrosion rate in chloride media. Author (NSA)

N67-19416*# Douglas Aircraft Co., Inc., Newport Beach, Calif. Astropower Lab.
STRESS CORROSION CRACKING OF TITANIUM ALLOYS AT AMBIENT TEMPERATURE IN AQUEOUS SOLUTIONS Quarterly Progress Report, Oct.–Dec. 1966
T. L. Mackay and C. B. Gilpin Jan. 1967 32 p refs
(Contract NAS7-488)
(NASA-CR-82796; SM-49105-Q2) CFSTI: HC $3.00/MF $0.65 CSCL 11F

Specimens of Ti–5Al–2.5Sn, Ti–6Al–4V, Ti–8Al–1Mo–1V and Ti–13V–11Cr–3Al were prepared for stress corrosion tests (single edge notch specimens), transmission electron microscopy, and electron microautoradiography. Stress corrosion tests in 3% sea water were initiated. K_c values for Ti–8Al–1Mo–1V in argon averaged 44.2 ksi$\sqrt{in.}$ whereas K_c values in sea water were between 18.5 and 28.0 ksi$\sqrt{in.}$ and in distilled water between 30.4 and 36.6. Electron microautoradiographic studies of the distribution of hydrogen in titanium alloys were initiated. Radioactive hydrogen (tritium) was introduced by cathodic charging and by gas adsorption at elevated temperature. Preliminary autoradiographs showed tritium introduced by cathodic charging to be distributed evenly throughout the lattice in the Ti–5Al–2.5Sn alloy. In the Ti–6Al–4V alloy no tritium was observed in the beta phase. At low charging current densities, tritium was evenly distributed in the alpha lattice, whereas at higher current densities tritium appeared to concentrate in alpha–beta boundaries and alpha–alpha boundaries. No tritium was observed in the beta alloy Ti–13V–11Cr–3Al. Author

N67-19495 Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
DETERMINATION OF AXIAL CONSUMPTION OF FLUID DURING ROTATION OF SHAFT
A. I. Belousov *In its* Aviation Eng., Vol. 7, No. 3 28 Sep. 1966 p 115–119 refs (See N67-19481 09-34) CFSTI: HC $3.00

Lubricant consumption along the axis of a working bearing under turbulent conditions of fluid flow is considered, taking into account the bearing shaft. There is a linear dependence of the square of the fluid consumption on pressure drop as the shaft rotates, and the additional resistance caused by rotation of shaft depends upon the geometry of the bearing slot. It is also noted that pressure drop is related to growth of peripheral velocity for a given slot. M.W.R.

N67-19581*# Atomic Energy Commission, Washington, D. C. Div. of Technical Information.
AEC–NASA LIQUID METALS INFORMATION MEETING
23 Apr. 1965 429 p refs 5th Meeting held at Gatlinburg, Tenn. and at Oak Ridge Natl. Lab., 21–23 Apr. 1965
(NASA-CR-82838; CONF-650411) CFSTI: HC $3.00/MF $0.65 CSCL 11F

In the conference papers presented, emphasis is placed on solubility studies and impurity effects in alkali metals; corrosion by liquid sodium, NaK, and lithium; and corrosion by boiling alkali metals. For individual titles, see N67-19582 through N67-19611.

N67-19588*# Oak Ridge National Lab., Tenn. Metals and Ceramics Div.
INTERACTIONS IN THE NIOBIUM–OXYGEN–POTASSIUM SYSTEM
A. P. Litman *In* AEC AEC–NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 61–62 (See N67-19581 09-17) CFSTI: HC $3.00/MF $0.65

To evaluate corrosion mechanisms in the Nb–O–K system, experiments were conducted in which the boundary conditions were temperatures of 200°, 600°, and 815°C; test times of 1 to 500 hours; and oxygen concentrations of 50 to 2600 ppm individually and collectively in the niobium and potassium. The results show: (1) Higher initial oxygen concentrations in niobium resulted in higher rates of oxygen transfer and more rapid production of surface scale. An initial concentration of approximately 1000 ppm was a prerequisite for subsurface corrosion formation. (2) Surface scales were observed when the initial oxygen in the potassium was 50 ppm. Higher oxygen concentrations in the potassium induced

more rapid thickening of the surface products on the niobium. (3) Higher test temperatures produced thicker surfaces on the niobium and caused the subsurface phase to form more quickly. The mass transfer of oxygen and niobium progressed rapidly as the temperature was raised. (4) Maximum scale thickness was observed at 25 hours at elevated temperatures. M.G.J.

N67-19592*# General Electric Co., San Jose, Calif. Atomic Products Div.

MASS TRANSFER STUDIES IN SODIUM

R. W. Lockhart *In* AEC AEC–NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 101–107 refs (See N67-19581 09-17) CFSTI: HC $3.00/MF $0.65

Test conditions are reviewed, along with the operation of the six test loops. Summary information is presented on the various experiments, the long exposure corrosion rate data are plotted, and the corrosion rate prediction formula is given. Among the results reported are: (1) Exposure effects or corrosion rates are location- and geometry-dependent. (2) Long term corrosion rates appear to be linear with respect to time and independent of alloy combinations. (3) Metallic surface layers exposed to 1100° to 1200°F sodium develop a perturbed composition which is sensitive to the oxygen plugging temperature. (4) Steady state corrosion appears to be stoichiometric and independent of the perturbed layer composition. (5) Chemical analysis of the saturated metallic impurities in the sodium are 800 to 1000 times as great as calculated from corrosion rate data, which suggests an alloy or oxide activation potential mass transfer model rather than a metallic solubility model. M.G.J.

N67-19594*# Oak Ridge National Lab., Tenn. Metals and Ceramics Div.

COMPATIBILITY STUDIES OF MATERIALS IN SNAP-8 PRIMARY SYSTEM

B. Fleischer, A. Taboada, W. R. Huntley, H. W. Savage, and R. E. MacPherson *In* AEC AEC–NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 119–129 refs (See N67-19581 09-17) CFSTI: HC $3.00/MF $0.65

Summary data are presented to show the effects of hot-leg temperature, hydrogen, oxygen content, and time on the corrosion of materials in the SNAP-8 forced-flow NaK corrosion loops. The findings indicate: (1) Increasing the hot-leg temperature from 1300° to 1400° F significantly affects Hastelloy N corrosion, only slightly affects type 347 stainless steel corrosion. (2) Hydrogen does not deleteriously affect corrosion of any materials. (3) Increasing oxygen from <30 ppm to approximately 80 ppm increases the corrosion rate of the iron-base alloys, has little effect on the nickel-base alloy. (4) The effect of time is approximately linear for Hastelloy N, but somewhat less than linear for type 347 stainless steel. In analyzing the corrosion mass transfer products in the high oxygen loops, a nonmagnetic complex oxide, identified as sodium–chromite, was found. Extensive carbon migration was also noted in both the 1300° and 1400°F loops. M.G.J.

N67-19595*# Aerojet-General Nucleonics, San Ramon, Calif.

STATUS OF SNAP 8 NaK CORROSION PROGRAM AT AGN

B. E. Farwell and M. F. Parkman *In* AEC AEC–NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 121–129 refs (See N67-19581 09-17) CFSTI: HC $3.00/MF $0.65

The corrosion and mass transfer patterns created by the NaK loop are being evaluated. The system design and operating history are outlined, and the temperature profile through the boiler is depicted. It is shown that as the run progressed, the NaK profile steepened so that the maximum 1300°F temperature was reached at about the 30 ft mark after 2000 hours; it remained fairly constant until final shutdown after some 4400 hours. Following sigma phase embirttlement of the NaK heater, failure was attributed to thermal shock caused by the cold NaK entering the heater from the purification system. No detrimental effects of any kind were noted in the heat rejection loop. M.G.J.

N67-19596*# Battelle Memorial Inst., Columbus, Ohio.

REFRACTORY METALS IN LITHIUM AT ELEVATED TEMPERATURES

J. A. De Mastry and N. M. Griesenauer *In* AEC AEC-NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 130–136 Sponsored by AF (See N67-19581 09-17) CFSTI: HC $3.00/MF $0.65

Experimental details are given on tests conducted to determine the resistance of certain refractory metals to attack by liquid lithium in the 2500° to 3000°F temperature range. These materials included tungsten, W–15Mo, W–25Re, TZM, Ta–12W, and Nb–5Mo–5V-1Zr specimens which were loaded into a TZM corrosion capsule. Sufficient lithium to completely cover the specimens at temperature was loaded into each capsule at room temperature to minimize contamination. The capsules were welded, then heat treated in vacuum resistance furnaces for 100 or 1000 hours at 2500°, 2800°, or 3000°F. After furnace cooling the corrosion capsules were opened in a helium glove box and the contents examined. Among the results reported are: (1) The tungsten-base materials undergo moderate to severe surface dissolution when exposed to static lithium at 2800°F and above. (2) Outstanding resistance to attack by lithium at 3000°F for up to 1000 hours is shown ty TZM. M.G.J.

N67-19598*# Oak Ridge National Lab., Tenn. Metals and Ceramics Div.

CORROSION OF ADVANCED REFRACTORY ALLOYS IN LITHIUM

C. E. Sessions *In* AEC AEC–NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 143–148 refs (See N67-19581 09-17) CFSTI: HC $3.00/MF $0.65

Static and thermal convection loop tests for evaluation of high temperature compatibility of lithium and refractory alloys are reported. Exposure to lithium was at either 500° or 1000°C for 100 hr, pretest oxygen levels were adjusted in the range 100 to 3000 ppm O, and selected specimens were vacuum heat treated at 1000° to 1600°C. The results are tabulated, and the corrosion behavior of Nb–1% Zr is discussed. Procedures are outlined for testing small loops in a stainless steel bell jar with a vacuum of 10^{-8}–10^{-9} torr to determine the compatibility of the alloys in flowing, nonisothermal lithium at elevated temperatures. The Nb–1% Zr loops were operated for a 3000 hour test with a maximum hot leg temperature of 1200°C and a temperature drop of approximately 120°C. One loop contained 58 Nb–1% Zr specimens interlocked continuously around the loop, and the second contained TZM inserts with six Nb–1% Zr inserts. Data on weight change profiles are graphed and discussed. N.E.N.

N67-19599*# General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.

NEW COMPONENTS FOR REFRACTORY METAL–ALKALI METAL CORROSION TEST SYSTEMS

E. E. Hoffman and J. Holowach *In* AEC AEC–NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 149–214 refs (See N67-19581 09-17) CFSTI: HC $3.00/MF $0.65

Vacuum test chamber components, reflux capsule corrosion test components, and components of forced circulation, two-fluid corrosion test loop systems are discussed. The components were evaluated in connection with the potassium corrosion test loop program. Details are presented on the getter-ion pumps to produce high vacuum test chamber environments. Components for the reflux capsule corrosion test include those connected with test specimen preparation, accurate temperature measurement, reflux rate measurement, and boiling stability. Components for the forced convection loop described are: liquid metal pumps, flow control and isolation valves, resistance heaters, reflective insulation, vapor bubble nucleators, liquid metal boilers, turbine simulator, condenser and subcooler, and temperature and pressure measuring devices. N.E.N.

N67-19600*# Brookhaven National Lab., Upton, N. Y.
A SUMMARY OF THE HIGH TEMPERATURE ALKALI METAL CORROSION PROGRAM AT BROOKHAVEN NATIONAL LABORATORY
A. J. Romano, A. H. Fleitman, and C. J. Klamut *In* AEC AEC–NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 217–234 (See N67-19581 09-17) CFSTI: HC $3.00/MF $0.65

Research to evaluate refractory metals and alloys for containing liquid and boiling sodium in the temperature range 1000°–1315°C are summarized. Emphasis was placed on the evaluation of Nb–1Zr in capsules and loops, and the results are described and tabulated. Tests on Ta base alloys and other Nb base alloys are also described. N.E.N.

N67-19601*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUMMARY OF THE POTASSIUM–REFRACTORY METAL CORROSION CAPSULE PROGRAM AT NASA LEWIS RESEARCH CENTER
C. M. Scheuermann *In* AEC AEC–NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 235–236 (See N67-19581 09-17) CFSTI: HC $3.00/MF $0.65

A refractory metal corrosion capsule program, whose purpose is to test the corrosion resistance of potential niobium and tantalum tubing alloys to boiling potassium, is reviewed. The materials being studied and their nominal compositions are presented in tabular form. The tests which were conducted, using refluxing capsules made of the test alloy red stock, machined to 1/2-in. diameter, 1-3/4 in. length, and 0.040-in. wall thickness, are briefly described. Preliminary results obtained from the tests are summarized for the following materials: B-33; SNb-291; Nb–1Zr; Ta–10W; X-110; D-14, B-66, Nb-752, AS-55, and C-129; FS-85; and T-111. L.E.W.

N67-19603*# General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.
POTASSIUM CORROSION STUDIES
R. G. Frank *In* AEC AEC–NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 272–315 refs (See N67-19581 09-17) CFSTI: HC $3.00/MF $0.65
(Contracts NAS3-2140; NAS3-2534; NAS3-2547; NAS3-6012)

The aim of the corrosion investigations is to advance the technology underlying the development of turboelectric space power generating systems. Although the corrosion investigations have included studies with potassium, sodium, and cesium, the fluid receiving the major attention is potassium. The following corrosion programs are described: 1) 5,000- and 10,000-hr refluxing potassium tests of advanced niobium containment alloys, 2) refluxing potassium compatibility tests between Nb–1Zr alloy and Mo–TZM alloy, 3) refluxing potassium stress-corrosion tests with D-43 alloy, 4) isothermal potassium compatibility tests between Nb–1Zr alloy and potential journal bearing materials, 5) isothermal potassium compatibility tests between Nb–1Zr alloy and stainless steel, 6) natural convection and forced circulation liquid sodium loop tests, and 7) forced circulation boiling potassium loop tests. *Author*

N67-19605*# MSA Research Corp., Callery, Pa.
FACTORS AFFECTING THE COMPATIBILITY OF LIQUID CESIUM WITH CONTAINMENT METALS
F. Tepper and J. Greer *In* AEC AEC–NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 323–333 (See N67-19581 09-17) CFSTI: HC $3.00/MF $0.65
(Contract AF 33(657)-9168)

A study made to assess the factors affecting the corrosion of structural metals by liquid cesium is summarized, and details are given on the following aspects: solubility of carbon in cesium, metal solubility studies, reflux capsule investigations, and dissimilar metal tests. Procedures used for the analysis of carbon in cesium are outlined, as well as the sampling procedure and oxygen analysis. The solubility of carbon in cesium was determined to 1200°F and the effect of carbon on the melting point of cesium was also examined. Data derived from metal solubility tests using tip capsules are presented in tabular form. Cesium boiling refluxing tests were performed with a number of alloys including L-605, TD–Ni, Mo–1/2Ti, Nb–1Zr, Ta–10W, and Nb–27Ta–12W–1/2Zr. Summary details are given on dissimilar metal studies performed at 1800°F in the case of L-605 and TD–Ni, and in the range 2100° to 2500°F for refractory metal alloys. L.E.W.

N67-19607*# Battelle Memorial Inst., Columbus, Ohio.
REFRACTORY METALS IN 1370–1870°C CESIUM VAPOR
J. A. DeMastry and N. M. Griesenauer *In* AEC AEC–NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 337–343 Sponsored by AF (See N67-19581 09-17) CFSTI: HC $3.00/MF $0.65

The corrosion resistance to cesium vapors was determined for tungsten, W–15Mo, W–25Re, TZM, Ta–12W, and Nb–5Mo–5V–1Zr. Specimens about a half-inch long were loaded into a TZM corrosion capsule, melted cesium was inserted, and the capsules were then heat treated in a vacuum resistance furnace for 100 or 1000 hours. Unalloyed tungsten was not attacked by cesium vapors. The W–15Mo alloy was not attacked during 100 hours but was severely attacked during 1000 hours at 3400°F. The W–25Re alloy exhibited the most resistance of the tungsten alloys to attack. The TZM alloy had outstanding resistance to the vapor attack. The Ta–12W specimens were not corroded after 100 hours, but showed severe surface dissolution after 1000 a hours at 2500°F, and the Nb–5Mo–5V–1Zr alloy was more resistant than the Ta–12W alloy. It was felt that tungsten and tungsten–base alloys should be useful thermionic emitters up to 3100°F, and TZM up to 3400°F. N.E.N.

N67-19609*# Westinghouse Electric Corp., Pittsburgh, Pa. Astronuclear Lab.
T-111 CESIUM NATURAL CONVECTION LOOP
R. L. Ammon, R. T. Begley, and R. L. Eichinger *In* AEC AEC–NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 359–373 refs (See N67-19581 09-17) CFSTI: HC $3.00/MF $0.65

This paper describes the construction, operation, and analysis of a cesium natural convection loop. The purpose of this program was to evaluate the corrosion resistance of T-111 (Ta-8W-2Hf) in cesium liquid and vapor, and to acquire operating experience on a high temperature two-phase cesium loop. Preliminary studies of the compatability of T-111 with Cs were accomplished by means of refluxing capsule tests at a maximum temperature of 2500°F. Metallographic examination of T-111 capsules which operated 100 and 750 hours indicated no significant corrosion effects. *Author*

N67-19610*# Pratt and Whitney Aircraft, Middletown, Conn. CANEL Div.
CORROSION STUDIES OF REFRACTORY METAL ALLOYS IN BOILING POTASSIUM AND LIQUID NAK
In AEC AEC–NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 374–393 refs (See N67-19581 09-17) CFSTI: HC $3.00/MF $0.65

Compatibility evaluations were made in gravity-feed potassium loops at temperatures up to 2000°F on the following materials: Nb-1 Zr, PWc-533 (C–Mo–Nb–Ti–Zr) PWC-11 (C-Nb-Zr). Type 316 stainless steel, and No-TZM. The evaluations were based on weight changes, chemical analyses, metallographic examinations, and mechanical strengths. A study was also made of interactions of Nb-1 Zr specimens in a Type 316 stainless steel-eutectic NaK loop operated at 1250°F. NSA

N67-19611*# Pratt and Whitney Aircraft, Middletown, Conn. CANEL Div.
CRITIQUE OF SESSION ON CORROSION BY BOILING ALKALI METALS

K. J. Kelly *In* AEC AEC–NASA Liquid Metals Inform. Meeting 23 Apr. 1965 p 394–397 (See N67-19581 09-17) CFSTI: HC$3.00/MF$0.65

Conference papers on boiling alkali metal programs are summarized, and increased development of alkali metals for Rankine and thermionic power conversion applications are reported. Areas of improved techniques are stressed, and observations which appeared preeminent are outlined. N.E.N.

N67-19675# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

EFFECT OF SULFUROUS COMPOUNDS ON THERMAL STABILITY AND CORROSIVE PROPERTIES OF FUELS FOR TURBOCOMPRESSOR AIR-REACTIVE ENGINES

P. I. Davydov and G. F. Bol'shakov 25 Apr. 1966 15 p Transl. into ENGLISH of the Publ. "Bor'ba s Korroziyey Dvigateley Vnutrennego Sgoraniya i Gazoturbinnykh Ustanovok" USSR, 1962 p 272–280

(FTD-TT-65-1276; TT-66-62520; AD-641109) CFSTI: HC $3.00/MF$0.65

Conclusions: (1) Aliphatic cercaptanes, contained in fuel as a result of long heating at 150 degrees, cause sharp corrosion of bronze and formation of tars and insoluble residue. It is necessary to reduce the mercaptan content in fuel. (2) The investigated sulfurous compounds, by their corrosive effect on metals and the effect of tar and residue formation processes in fuels during their heating to 150 degrees, are divided into the following descending series: mercaptanes, disulfides, aliphatic sulfides, aromatic sulfides, thiophanes. Author (TAB)

N67-19720# Massachusetts Inst. of Tech., Cambridge. Instrumentation Lab.

BALL MOTION IN ANGULAR CONTACT BEARINGS

Edward P. Kingsbury Oct. 1966 23 p refs

(Contract AF 33(615)-2243)

(E-2036; AD-643262) CFSTI: HC$3.00/MF$0.65

The nature of the frictional forces and moments applied to an angular contact bearing ball is examined in terms of slip, pivoting, spin and precession. Experimental methods for determining these quantities are given, together with results which indicate that the ball is retainer-controlled for pivoting, and race-controlled for slip. Author (TAB)

N67-19815# Springfield Armory, Mass.

MODERN, EXTREME PRESSURE-TYPE, WATER-BASE, METAL-WORKING LUBRICANTS

M. S. Spivak 15 Apr. 1966 60 p refs

(SA-TR16-1062; AD-643157) CFSTI: HC$3.00/MF$0.65

Preliminary experiments were conducted to establish parameters for the development of a test or tests so that performance characteristics of metal-working lubricants could be evaluated. Selected proprietary cutting-fluids were compared for performance in the Falex and in the Shell four-ball machines. The water and volatile content of each cutting-fluid concentrate was determined. Infrared spectra were obtained and data interpreted for each of the dehydrated, devolatilized concentrates. The presence of sulfur and metallic constituents in the concentrates was established. A modified Falex test procedure is outlined. A number of infrared spectra of typical compounds, used in the cutting-fluid formulations, are presented. Results of testing and comparisons indicate the complexity of the problem and the need for development or a workable and reproducible performance evaluation procedure. Author (TAB)

N67-19969 Saunders-Roe, Ltd. (Gt. Brit.)

PIN FRETTING FATIGUE IN ALUMINUM ALLOY LUGS, PART 4

A. W. Andrews, E. Heber, and F. A. Kerry Apr. 1966 54 p refs

(Contracts KS/6/EXP/3113/CB.38b;KS/1/0202/CB.43(a)2)

(S&T-Memo-11/65)

Tests were carried out to determine the effects of various jointing compounds on the fretting fatigue characteristics of aluminium alloy lugs. Work was carried out using D.T.D.363, L.65, and D.T.D.5054 lugs and Rotol ASP, D.T.D.5530, Duralac 3389, Duralac 6236, and British Timken Frin jointing compounds. Tests were carried out at three levels of mean stress, each level with a range of dynamic stresses. Tests were also carried out on compounds, greases, and special treatments which had not been tested previously. The best results were obtained with lugs in which the holes had been work hardened by pressing through a 1.5% oversize hardened steel ball (ballized). Author

N67-19997*# General Electric Co., Cincinnati, Ohio Space Power and Propulsion Section.

ADVANCED REFRACTORY ALLOY CORROSION LOOP PROGRAM Quarterly Progress Report, 15 Jul.–15 Oct. 1966

R. W. Harrison, ed. and E. E. Hoffman 24 Oct. 1966 33 p refs (Contract NAS3-6474)

(NASA-CR-72177; QPR-6) CFSTI: HC$3.00/MF$0.65

Status of a program to fabricate, operate for 10,000 hours, and evaluate a potassium corrosion test loop constructed of T-111 (Ta-8W-2Hf) alloy is presented. Materials for evaluation in the turbine simulator included Mo-TZC and Cb-132M. Data are presented for the microhardness and grain size of unannealed and annealed T-111 alloy and also for the longitudinal microstructure of T-111 alloy tubing. Data are also tabulated for the chemical analyses and mechanical properties of Cb-132M alloy. An annealing treatment is discussed for the Mo-TZC alloy, and alkali metal purification and handling is briefly described. A study to evaluate the corrosion resistance of two advanced tantalum alloys to potassium and lithium is described. S.P.

N67-20013*# General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.

EVALUATION OF HIGH STRENGTH COLUMBIUM ALLOYS FOR ALKALI METAL CONTAINMENT Final Report, 25 Jul. 1962–15 Dec. 1964

L. B. Engel, Jr. and R. G. Frank 15 Dec. 1964 100 p refs

(Contract NAS3-2140)

(NASA-CR-82995; R66SD3015) CFSTI: HC $3.00/MF $0.65 CSCL 11F

Corrosion testing of four reflux capsules, two AS-55, one Nb–1Zr, and one D-43, containing purified potassium, was conducted at 2000°F for 10,000 hr in an ultrahigh vacuum chamber and a vacuum in the 10^{-8} to 10^{-9} torr range was maintained throughout testing. The condensing rate of the potassium contained within capsules was approximately 37 ± 12 lb/hr/ft^2. Evaluation of the Nb–1Zr alloy capsule after exposure revealed a small amount of black deposit, accompanied by a gold discoloration of the metal around or near the deposits. These black deposits were identified as essentially pure zirconium with a high oxygen content; some niobium was also present. Evaluation of the AS-55 alloy capsule revealed discoloration but the extent was significantly less than that found in the Nb–1Zr alloy capsule. An improved potassium transfer system was employed to fill the second AS-55 alloy capsule and the D-43 alloy capsule, and no signs of staining were observed. Chemical analyses revealed no significant mass transfer of carbon with either the AS-55 or D-43 alloy. Author

N67-20165# Royal Aircraft Establishment, Farnborough (England).

A PRELIMINARY INVESTIGATION OF HIGH RATE COMPACTION OF POWDERS USING THE PETROFORGE

R. C. Fullerton-Batten Apr. 1966 24 p refs

(RAE-TR-66136) CFSTI: HC$3.00/MF$0.65

Some experiments are described on the high rate compaction of copper and Cu–MoS_2 powders. A comparison is made between the properties of the resulting compacts and those for compacts prepared by slow pressing. The high rate process gives green compacts of higher density and hardness, but entrapped air

causes cracking and deformation during subsequent heat treatment. Compacting in vacuum should help to overcome this disadvantage. Author

N67-20173# Naval Civil Engineering Lab., Port Hueneme, Calif.
CORROSION OF MATERIALS IN HYDROSPACE Technical Report, Mar. 1962–Jun. 1966
Fred M. Reinhart Dec. 1966 117 p refs
(R-504; AD-644473) CFSTI: HC$3.00/MF$0.65

A total of 1,590 specimens of 107 different alloys were exposed at depths of 2,340, 5,300, and 5,640 feet at two sites in the Pacific Ocean for 197, 1,064, and 123 days to determine the effects of deep ocean environments on the corrosion of materials. The corrosion rates, pit depths, types of corrosion, changes in mechanical properties, and analyses of corrosion products of the alloys are presented. Titanium alloys and two nickel base alloys (Ni-Fe-Cr-825 and Ni-Mo-Cr-C) were immune to corrosion. The corrosion rates of copper alloys and steels decreased with a decrease in the oxygen concentration of the seawater and with increasing time of exposure at a nominal depth of 5,500 feet. The corrosion rates of most of the aluminum alloys increased with increasing time of exposure and with decreasing oxygen concentration of seawater. Muntz metal, and nickel-manganese bronze were attacked by dezincification and aluminum bronze by dealuminification. All the stainless steels except types 316 and 316L, 20-Cb and 17 Cr - 7 Ni - 0.7 Ti- 0.2 Al were attacked by pitting corrosion. Only two precipitation hardened stainless steels were susceptible to stress corrosion cracking. The oceanographic parameters varied with depth. Changes in temperature and oxygen concentration exerted the most influence on the corrosion of the alloys. Author (TAB)

N67-20331# Royal Aircraft Establishment, Farnborough (England).
THE FRICTION AND WEAR OF CARBON FIBRE-REINFORCED POLYESTER RESIN
R. F. Fullerton-Batten and J. K. Lancaster Aug. 1966 19 p refs
(RAE-TR-66247) CFSTI: HC$3.00/MF$0.65

Experiments are described which examine the effect of reinforcement by carbon fibers on the friction and wear of polyester resin sliding either against itself or tool steel. It is shown that reinforcement can significantly reduce both the coefficient of friction and the rate of wear, the maximum effect being achieved when the fiber axes are oriented normal to the sliding surface. In these conditions it is suggested that the fibers act as preferential load-bearing contact regions. Author

N67-20831# Babcock and Wilcox Co., Alliance, Ohio. Research Center.
MATERIALS EXAMINATION OF A MODEL SODIUM HEATED STEAM GENERATOR Final Report
D. W. Koch and P. J. Kovach 30 Jun. 1966 75 p refs
(Contract AT(11-1)-1280)
(BAW-1280-37; RR-5136) CFSTI: HC$3.00/MF$0.65

A test program was conducted to assess the compatibility of Croloy 2-1/4 and type 316 stainless steel in a liquid Na system. A single tube steam generator was designed to model 1000-Mw(e) steam generator design parameters, and samples were removed from the pipe after 1000 to 8000 hr operation at 600 to 1000°F (Croloy 2-1/4) and 800 to 1100°F (type 316 stainless steel). During exposure, the Croloy 2-1/4 surface partially decarburized to depths of 20–25 mils and was enriched in Ni, Cr, and O. The mass transfer from the type 316 stainless steel, confined within 8 microns of the surface, consisted of depletions of Ni and Cr and an enrichment in Fe. The stainless steel also carburized at the Na surface but was sensitized throughout. The mechanical property studies were inconclusive owing to the tempering effects of the exposure. The waterside corrosion behavior in the model was similar to that in conventional steam generators. It is concluded that Croloy 2-1/4 and type 316 stainless steel as construction materials are satisfactory. NSA

N67-20846# Phillips Petroleum Co., Idaho Falls, Idaho. Atomic Energy Div.
NUCLEAR TECHNOLOGY BRANCHES Quarterly Report, 1 Jan.–31 Mar. 1966
E. E. Burdick et al Aug. 1966 53 p refs
(Contract AT(10-1)-205)
(IDO-17192) CFSTI: HC$3.00/MF$0.65

The power distribution was measured in the ATR 39-kg core in a nominal 50–50–50 power split in the ATRC. Thermal flux and fission rate data were obtained in experiment irradiation holes. Extrapolated hot-spot power generation would be 26.2 Mw/kg at 250 Mw. Reactivity worths and calibration curves of outer shims and regulating rods in this core are presented. Be irradiated at 600°C to exposures of approximately 1×10^{21}n/cm^2>1 Mev was compression tested, and the He gas release was measured. The failure mechanism was noted, and electron fractographs of the gas bubble formation are given. The procedures used for the preparation of Resonance Integral Measurement Samples are described. These involve the use of power metallurgical techniques to produce tubular specimens containing rare earth oxides dispersed in Al. Electroless Ni–coated 6061 Al samples were corrosion tested in a pressurized water loop at 190°C and 45 ft/sec. Various heat treatments were studied. The best corrosion resistance was produced by a 54-hour, 410°C air heat treatment. Results of analysis of the structural behavior of the ATR fuel element from the thermal differences present during operation are described. Selective loading of the fuel in ATR fuel elements to decrease the beginning-of-life temperatures is examined. The results of the thermal and structural calculations for one radially variable fuel element are compared to the reference design. The energy of the hydrogen-neutron-capture gamma ray was measured, using a Li-drifted Ge detector, to be 2223.29±0.07 keV. Based upon this result, the binding energy of the deuteron was determined to be 2224.61±0.07 keV. The energy levels in ^{149}Sm were studied by means of the radioactive decay of ^{149}Pm and ^{149}Eu. Gamma-ray and conversion-electron spectra were obtained along with gamma-gamma coincidence spectra. All 29 gamma-ray transitions observed in these two activities were placed in schemes with levels in ^{149}Sm at 22.5, 277.0, 285.9, 350.0, 528.5, 558.4, 590.9, 636.4, 830.4, 833.2, and 881.9 keV. Author (NSA)

N67-20890# Ohio State Univ. Research Foundation, Columbus.
A STUDY OF THE MECHANISM OF STRESS CORROSION CRACKING IN THE IRON–NICKEL–CHROMIUM ALLOY SYSTEM Quarterly Report, 17 Mar.–16 Jun. 1966
R. W. Staehle 30 Aug. 1966 56 p
(Contract AT(11-1)-1319)
(COO-1319-42) CFSTI: HC$3.00/MF$0.65

Stress corrosion cracking experiments are reported in dilute chloride environments at 500°F and in boiling $MgCl_2$ environments. Data are reported in terms of % unbroken vs time. Studies on effect of surface preparation are reported. Results of these studies show that various surface preparations greatly affect mean cracking times and can cause significant differences in data scatter. A study of the effect of alloy composition on annealing twin frequency was completed and final results show generally that increasing the Ni and Cr increases the frequency of annealing twins. Results are reported from a study of tensile properties as a function of temperature and alloy composition. A potentiokinetic polarization study was completed for the ternary Fe–Cr–Ni alloy system and results are summarized graphically. Figures presenting concepts in the theory of stress corrosion cracking are included. Author (NSA)

N67-20928# Atomic Energy of Canada, Ltd., Chalk River (Ontario).
FORMING UNIFORM THICK OXIDE LAYERS ON ZIRCALOY-2 FOR FRICTION AND WEAR APPLICATIONS IN HIGH TEMPERATURE WATER
R. D. Watson Mar. 1966 33 p refs
(AECL-2542) Available from Atomic Energy of Canada, Ltd., Chalk River: $1.00

Several methods of producing uniform buff oxide layers in Zircaloy-2 were developed. The oxidized material has excellent wear resistance and should be useful for parts in rubbing contact in water-lubricated mechanisms operating at 500°F. The oxidation rate of Zircaloy-2 in air is dependent on the surface texture and the treatment given it. A rough surface produced by machining or grit blasting assures formation of uniform buff post-transition oxide layers. Fine surfaces produced by grit blasting, polishing, machining or grinding decrease the oxidation rate and prevent formation of uniform buff post-transition oxides. Deep scratches increase the oxidation rate apparently because of the surface roughness produced. The oxidation resistance of machined, ground, or polished Zircaloy-2 is not improved by pickling. Author (NSA)

N67-21014# Atomic Energy of Canada, Ltd., Chalk River (Ontario).
WEAR AND CORROSION IN WATER
R. D. Watson 19 Feb. 1966 85 p refs Revised
(AECL-2566; EDI-67, Rev.) Available from Atomic Energy of Canada, Ltd., Chalk River: $2.00

The wear resistance of a number of different combinations of materials was investigated in water at room temperature. For journal bearing applications, it was found that the different combinations could be divided into two groups: those that wear at a constant rate; and those that wear at a continually decreasing rate. The first group covers those combinations that cannot provide a suitable surface finish on the rubbing surfaces through wear to allow the formation of a thin supporting film of fluid. The second group combinations produce fine abrasive wear and provide polished surfaces that can sustain thin films which will support all or part of the load. The wear resistance of thin stable metallic oxides was investigated. The crevice corrosion resistance of a number of compatible combinations was studied in different aqueous environments. Author (NSA)

N67-21055# European Atomic Energy Community, Brussels (Belgium).
INFLUENCE OF SURFACE TREATMENT ON VARIOUS TYPES OF STAINLESS STEELS CORROSION
J.-Ph. Berge Dec. 1966 16 p refs Presented at the 3d Intern. Congr. on Metallic Corrosion, Moscow, 16–25 May 1966
(EUR-2891.e; EURAEC-1709) CFSTI: HC$3.00/MF$0.65

The effects of the chemical, physical, microgeometric (roughness) surface state characteristics on various types of corrosion in stainless steels are discussed. Anodic passivation, stress corrosion, intergranular corrosion, and corrosion in steam at high temperature are discussed. Methods used to determine the surface state characteristics are described. The examples given show that in general a surface state cannot be adequately determined by the roughness value alone. L.S.

N67-21060 Westland Aircraft, Ltd., Yeovil (England). Saunders Roe Div.
FRETTING FATIGUE OF JOINTS. PART 5: STEEL LUGS
A. W. Andrews, E. Heber and F. A. Kerry London, Min. of Aviation, Apr. 1966 9 p
(Contract KS/1/0202/CB.43(a)2)
(S&T-MEMO-12/65)

The fretting fatigue characteristics of pin joints in DTD 473 high tensile steel and the effect of several jointing compounds or special treatments to either the pin or the hole in the lug were investigated. The compounds chosen were those that had given the best results in the work on aluminium alloy lugs Duralac 4678 and 8817, British Timken Frin, and Duckhams Keenomax C3. None of the compounds showed any marked advantage over a sample of one of the standard jointing compounds commonly used. Author

N67-21212# Atomic Energy of Canada, Ltd., Chalk River (Ontario).
WEAR OF PLASTICS IN ROOM TEMPERATURE WATER
J. T. Dunn Feb. 1966 40 p refs
(AECL-2532) CFSTI: HC$3.00/MF$0.65

The wear resistance of 22 self-lubricating plastics was determined in 80 to 160°F high purity water as 3/4 in. sleeve bearings against type 304 stainless steel journals. Carbon filled Tetrafluoroethylene (TFE) and high density polyethylene had the highest wear resistance over the range of loads and speeds used (18–108 lb/in^2 and 8–55 ft/min). In all cases the wear on the stainless steel journals was negligible compared to the wear on the plastic. In 80% of the tests the wear rates decreased with increasing sliding distance. This appeared to be the result of the gradual increase of hydrodynamic lubrication in the bearing wear-scar aided by lubrication from transferred films. Filled TFE materials improved in wear resistance after gamma irradiation under water to 1.5 ± 10^7 roentgens while nylon, phenolic, epoxy and Vespel showed a decrease after an exposure of 6×10^7 roentgens. Author

N67-21222# Israel Program for Scientific Translations, Ltd., Jerusalem.
CURRENT STATE AND PROSPECTS OF THE APPLICATION OF RADIOISOTOPES AND NUCLEAR RADIATION IN MACHINE BUILDING
S. V. Rumyantsev *In its* The Uses of Radioact. Isotopes and Nucl. Radiation in the U.S.S.R. Vol. III: Machine Bldg., Met. 1966 p 1–7 (See N67-21221 10-15) CFSTI: HC$3.00/MF$0.65

Use of radioisotopes in the quality control of technological processes and inspection of manufactured products is reviewed; and specific applications for theoretical and practical researches in metallurgy, foundry operations, and welding are mentioned. An overview is included of radioisotope and nuclear radiation applications to wear studies aimed at increasing the service life of machine components and cutting tools used in industry; and savings to the national economy are cited for gamma flaw detection programs used in several industrial processes. M.W.R.

N67-21236# Israel Program for Scientific Translations, Ltd., Jerusalem.
METHOD FOR STUDYING THE WEAR OF TRACTOR COMPONENTS WITH RADIOISOTOPES UNDER WORKING CONDITIONS, AND EXPERIENCE GAINED IN ITS INTRODUCTION
I. N. Velichkin, A. I. Nisnevich, and V. S. Tunitsyn *In its* The Uses of Radioact. Isotopes and Nucl. Radiation in the U.S.S.R. Vol. III: Machine Bldg., Met. 1966 p 60–64 (See N67-21221 10-15) CFSTI: HC$3.00/MF$0.65

Wear of engine and other tractor components under operating conditions is studied with cobalt 60 as a tracer. Wear of upper compression rings mounted on a tractor engine is graphed; and differences are noted for various temperature and atmospheric conditions. Results are also shown for wear of piston rings under different working conditions. Use of the outlined technique has prevented an excessive wear of rings under winter conditions, and has increased by about 50% the wear-resistance of components in the cylinder–piston assembly during the service life of the engine on which these studies were made. M.W.R.

N67-21238# Israel Program for Scientific Translations, Ltd., Jerusalem
STUDIES OF THE EFFECT OF THE COMBUSTION PROCESS ON THE WEAR OF COMPRESSION RINGS IN THE DIESEL ENGINE
B. P. Pakhomov *In its* The Uses of Radioact. Isotopes and Nucl. Radiation in the U.S.S.R. Vol. III: Machine Bldg., Met. 1966 p 69–72 (See N67-21221 10-15) CFSTI: HC$3.00/MF$0.65

Effect of various operating conditions on the vertical wear of the upper compression ring of a diesel engine was studied by radioisotope detection procedures. Load and rotational speed of the crankshaft were taken into account, and a preliminary investigation was made of the centrifuge efficiency and of the deposition of mechanical impurities on the walls of the cylinder and the oil manifold. At higher gas pressure values, an increase in load was found to increase wear; and an increase in the temperatures of the

exhaust gases caused a considerable increase in the vertical wear of the rings. Steps were, therefore, taken to remove heat from the zone of the upper compression ring. Results of this study were applied to production of high speed engines at a tractor plant. It is noted that the sensitivity of the procedures were low and that some of the instruments were not capable of determining slight changes in wear. M.W.R.

N67-21239# Israel Program for Scientific Translations, Ltd., Jerusalem.

RADIOISOTOPES IN MACHINING RESEARCH

E. P. Nadeinskaya *In its* The Uses of Radioact. Isotopes and Nucl. Radiation in the U.S.S.R. Vol. III: Machine Bldg., Met. 1966 p 73–81 (See N67-21221 10-15) CFSTI: HC $3.00/MF $0.65

Radioisotopes are found to be a reliable and economical means for studying the effect of the hardness and wear of high speed tool steel used in the machining of metal leads. Slight variations in steel hardness can be determined, and graphs are included to show the wear of cutting tools; effect of cutting speed, feed, quenching and tempering temperatures on wear; and effect of these temperatures on metal hardness. Optimum temperatures are included, and formulas are given for the rate of tool wear and for wear resistance of the cutting tool. M.W.R.

N67-21241# Israel Program for Scientific Translations, Ltd., Jerusalem.

SELECTION OF OPTIMUM CONDITIONS FOR THE HEAT TREATMENT OF CASEHARDENING STEEL OF THE 18KHNVA TYPE

G. N. Bakakin, K. S. Gerasimenko, V. I. Doshchechkin, I. M. Lyubarskii, and A. P. Lyubchenko *In its* The Uses of Radioact. Isotopes and Nucl. Radiation in the U.S.S.R. Vol. III: Machine Bldg., Met. 1966 p 86–88 (See N67-21221 10-15) CFSTI: HC $3.00/MF $0.65

Structural and physicomechanical properties were investigated for several grades of case-hardened steel in order to select optimum heat treatment conditions and to improve wear resistance capabilities. Metallographic investigations were made to determine phase composition and structure, and the distribution of alloying elements among their phases and within a single phase was determined autoradiographically by carbon 14 and carbon 51. The samples were activated for wear tests by introducing cobalt 60 into the molten steel or by neutron irradiation of the prepared specimens. Cooling rate after case-hardening affected the phase composition, phase substructures, and their saturation with alloying elements; and change in the wear resistance of the case-hardened layer occurred. Reducing the cycle and simplifying the heat treatment of the case-hardened layer markedly improved the wear resistance of the layer. Results are included for industrial and experimental studies. M.W.R.

N67-21250# Israel Program for Scientific Translations, Ltd., Jerusalem.

THE USE OF RADIOISOTOPES IN THE BLAST FURNACE SHOP OF THE METALLURGICAL PLANT IM. F. E. DZERZHINSKII

. G. Polovchenko, P. L. Gruzin, V. N. Afanes'ev, and A. G. Vasil'ev *In its* The Uses of Radioact. Isotopes and Nucl. Radiation in the J.S.S.R. Vol. III: Machine Bldg., Met. 1966 p 130–137 (See N67-21221 10-15) CFSTI: HC $3.00/MF $0.65

Varied uses of radioisotopes for the inspection and control of blast furnace processes are described. Determination can be made of gas flow velocities and the length of times the charged components stay in the blast furnace. Checking the wear of the hearth and crucible of blast furnaces is discussed, as are the movement of the charge in the furnace, the radiometric inspection of the level of stock in a blast furnace, and the control of charge loading. Radiometric control of the properties of the charge materials is considered, and a radiometric device is shown that inspects the size of coke lumps. M.W.R.

N67-21259# Israel Program for Scientific Translations, Ltd., Jerusalem.

INTRODUCTION OF RADIOMETRIC DENSITY GAGES AT THE MIZUR ORE-DRESSING PLANT

E. Ya. Ovcharenko, U. I. Kotik, L. I. Fainberg, G. V. Tuev, and V. V. D'yakonenko *In its* The Uses of Radioact. Isotopes and Nucl. Radiation in the U.S.S.R. Vol. III: Machine Bldg., Met. 1966 p 167–169 (See N67-21221 10-15) CFSTI: HC $3.00/MF $0.65

Industrial testing and use of radiometric density gauges are discussed in terms of control of pulp density and corrosive liquids at nonferrous metallurgical establishments. Investigations revealed a sharp decrease in errors when higher energies of cobalt 60 gamma radiation was used. Use of cesium gamma sources revealed errors of more than 2%, and cesium was considered applicable only if there were no elements of high atomic numbers in the controlled medium. The described radiometric gauge is considered useable in hydrometallurgical shops, for the production of titanium, magnesium, and other metals where corrosive media are involved; and for ferrous metallurgy, chemical, and coal establishments. M.W.R.

N67-21266# Israel Program for Scientific Translations, Ltd., Jerusalem.

RADIOMETRIC CONTROL OF THE DEGREE OF FRITTING AND WEAR OF THE HEARTH OF OPEN-HEARTH FURNACES

V. A. Machkovskii and M. M. Khil'ko *In its* The Uses of Radioact. Isotopes and Nucl. Radiation in the U.S.S.R. Vol. III: Machine Bldg. Met. 1966 p 194 (See N67-21221 10-15) CFSTI: HC $3.00/MF $0.65

The processes of fritting and wear of the hearths in open hearth furnaces was investigated by beta emissions from calcium 45, phosphorus 32, and strontium 89. Fritted layers up to 50 mm thick were most resistant, and at greater thicknesses there was a sharp increase in wear rate. Results indicate that the fritting layer of hearths should be burnt in at the maximum possible temperature, with scale used as the slagging unit. Heating of the magnesite layer for more than 40 or 50 minutes is found to be inefficient. Radiometric control methods resulted in a 40 minute reduction in in time required for hot patching of furnace hearths, and this was estimated to yield an annual increase of 20,000 tons in steel production. M.W.R.

N67-21455*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RECRYSTALLIZATION AND PREFERRED ORIENTATION IN SINGLE-CRYSTAL AND POLYCRYSTALLINE COPPER IN FRICTION STUDIES

Donald H. Buckley Washington, NASA, Mar. 1967 13 p refs (NASA-TN-D-3794) CFSTI: HC $3.00/MF $0.65 CSCL 11F

From the results of an investigation with single-crystal and polycrystalline copper sliding on aluminum in vacuum (10^{-11} torr) the following summation is made: Although differences in friction coefficients exist for single-crystal and polycrystalline copper at light loads, a nearly common friction coefficient is obtained for the two forms of copper at higher loads. This effect is due to surface recrystallization and preferred orientation of copper at the sliding interface. X-ray data indicate the surface recrystallized layers to be the same at a 1000-gram load. Author

N67-21479# Oak Ridge National Lab., Tenn.
MATERIALS COMPATIBILITY AND CORROSION STUDIES FOR THE ARGONNE ADVANCED RESEARCH REACTOR
J. C. Griess and J. L. English Nov. 1966 42 p refs
(Contract W-7405-ENG-26)
(ORNL-4034) CFSTI: HC $3.00/MF $0.65

A material compatibility and corrosion investigation was conducted to determine the extent of corrosion to be expected in certain parts of the Argonne Advanced Research Reactor (AARR). The areas of concern were the Be reflector, the Al beam tubes and the stainless steel fuel element cladding, all of which are exposed to the primary coolant. All experiments were conducted in deionized water with a specific resistivity of 1 million ohm–cm or greater. The Be was free of localized attack, and neither crevices nor contact with stainless steel or Al produced adverse effects. The ratio of Be surface area to volume of water in the AARR is 2.3 cm^2/liter and the Be reflector would be expected to corrode at a rate between 1.1 and 2.8 mils/yr, either of which would be acceptable. The corrosion of 6061-T6 Al, the material from which the beam tubes will be made, results in the formation of an insulating layer of corrosion products. Test results indicate that if the surface temperature of the beam tubes in the AARR can be maintained at 200°F or less, the rate of corrosion, and consequently the rate of corrosion-product buildup on the surfaces, will be low enough to prevent excessive temperatures in the beam tube walls. Tests showed that in type 304 stainless steel after a 1000-hr exposure at a heat flux of 4.0×10^6 Btu/hr-ft^2, numerous shallow (≈0.2 mil deep) cracks were present on the cooled surface. In a comparable test in which the heat flux was 2.1×10^6 Btu/hr-ft^2 (hot-spot heat flux for 100 Mw operation of AARR) and the exposure time was 2000 hr, no cracks were found. In view of the failures experienced in stainless steel fuel-element cladding in both pressurized and boiling water reactors, it is recommended that further investigation into this type of cracking be carried out. NSA

N67-21567# Combustion Engineering, Inc., Windsor, Conn. Nuclear Div.
CORRELATIONS BETWEEN SENSITIZATION AND STRESS CORROSION CRACKING OF 300 SERIES STAINLESS STEELS Final Summary Report
J. J. Koziol and S. S. Christopher Sep. 1966 82 p refs
(Contract AT(30-1)-3256)
(CEND-3256-264; EURAEC-1568) CFSTI: HC $3.00/MF $0.65

The effects of preoxidation and variations in surface conditions on the susceptibility to transgranular cracking of Types 304 and 347 stainless steel were studied. Tubing with annealed, drawn, swaged, and diffused Ni surfaces was exposed to an aqueous environment to evaluate the differences in behavior of nonstabilized and stabilized types (304 and 347) of stainless steels under identical test conditions. Tubes with swaged surfaces (15% R.A.) and surfaces containing diffused Ni layers showed improved resistance to transgranular cracking when compared with the other samples evaluated in this program. A trend toward increased susceptibility to transgranular cracking, which was observed for preoxidized and sensitized Type 304 stainless steel confirmed the possibility of interaction between grain boundary oxidation and transgranular cracking. Author (NSA)

N67-21575# Brookhaven National Lab., Upton, N. Y.
THE BEHAVIOR OF REFRACTORY METALS AND ALLOYS IN BOILING SODIUM AND OTHER ALKALI METALS
A. Romano, A. Fleitman, and C. Klamut [1966] 19 p refs Presented at the Intern. Atomic Energy Agency Symp. on Alkali Metal Coolants, Corrosion Studies, and System Operating Experience, Vienna
(Contract AT(30-2)-GEN-16)
(BNL-10723; CONF-661110-2) CFSTI: HC $3.00/MF $0.65

A study was undertaken to determine whether Na or Cs (boiling and liquid) can be contained in refractory metal alloys. Other alkali metals were also tested in these alloys to compare their corrosiveness with that of Na and Cs. Of all the refractory metal alloys tested, alloy FS-85 (Nb–27Ta–10W–1Zr) was the most susceptible to corrosion by Na; intergranular penetration as deep as 0.05 mm was detected in one test. Several other alloys exhibited very slight transgranular corrosion by Na, but most of the alloys were not attacked. None of the alloys seem to be susceptible to stress-induced corrosion. The compatibility of two alloys (Nb–1Zr and Nb–10W–1Zr) with Li, Na, K, Rb, and Cs was also evaluated. In general, very slight corrosion was detected in these tests; although K seemed to be the least aggressive of the alkali metals in Nb–1Zr, there was no corrosion of Nb–10W–1Zr detected. Of all the alkali metals, Cs offers the most attractive thermodynamic properties relative to optimum turbine design. The alloys TZM and TZC were tested under conditions of high velocity vapor impingement (245 m/sec) at 840°C for 1096 hr in a forced circulation loop fabricated completely of refractory metals. Results of this test showed no corrosion or erosion of either of the test materials but a 0.025 mm-thick deposit of Nb was found on each blade. Author (NSA)

N67-21648# General Electric Co., Schenectady, N. Y. Knolls Atomic Power Lab.
SINGLE PAN BALANCE WEIGHING OF CORROSION COUPONS
E. J. Callahan and A. C. Titus 30 Sep. 1966 20 p refs
(Contract W-31-109-ENG-52)
(KAPL-M-6577) CFSTI: HC $3.00/MF $0.65

A procedure has been derived to verify the Class S tolerances of the internal balance ring weights of a single-pan semimicro analytical balance, since gravimetric effects of corrosion can be observed more accurately when the analytical balance used to make gravimetric measurements is periodically calibrated. These procedures assure that anticipated small weight differences will be detected even though these values are close to the weighing accuracy of the balance. Author (NSA)

N67-21657# Los Alamos Scientific Lab., N. Mex.
A COMPARISON OF THREE METHODS OF OXYGEN CONCENTRATION MEASUREMENT IN SODIUM
Charles C. Mc Pheeters and James M. Williams [1966] 35 p refs Presented at the Intern. Atomic Energy Agency Symp. on Alkali Metal Coolants, Corrosion Studies, and System Operating Experience, Vienna
(Contract W-7405-ENG-36)
(LA-DC-7743; CONF-661110-5; SM-85/29) CFSTI: HC $3.00/MF $0.65

Two electrochemical oxygen meters, an ac resistivity meter, and a vacuum distillation sodium sampler were tested to determine their sensitivities and responses to oxygen concentration changes in sodium. These tests were conducted on an isothermal, forced convection sodium loop of large volume; a bypass cold trap provided for oxygen concentration control. A vacuum distillation analytical technique was used as the primary standard for measurement of the oxygen concentration. Experimentally determined calibration curves for the electrochemical cells agree closely with the theoretical predictions in the slope, but the emf values were approximately 85% of theoretical. The ac resistivity meter was calibrated by comparing per cent resistivity with vacuum distillation and analyses. The meter was found to have an oxygen concentration dependence of 0.0070% resistivity change per ppM weight change in oxygen concentration, compared to the predicted value of 0.01%. Later in the experiment this dependence was found to be 0.0139% resistivity change per ppM oxygen. This shift is attributed to the effect of other impurities added to the system. In order to determine the response times of the oxygen meters and the resistivity meter, a step change was made in the cold trap temperature. Within the error of the measurements, all instruments responded in good agreement with the vacuum distillation analyses. The total time elapsed from the beginning of the concentration

transient to system equilibrium was 130±10 hours. The efficiency for oxygen addition to the system from the cold trap was found to be 20%. NSA

N67-21738# Marine Engineering Lab., Annapolis, Md.
EFFECTS OF NOTCHES AND SALTWATER CORROSION ON THE FLEXURAL FATIGUE PROPERTIES OF STEELS FOR HYDROSPACE VEHICLES
M. R. Gross and E. J. Czyryca Oct. 1966 42 p refs
(MEL-420/66; AD-644147) CFSTI: HC $3.00/MF $0.65

The flexural fatigue behavior of five constructional steels was investigated in air and salt water over a broad life spectrum ranging from 1000 to 100 million cycles. The yield strengths of the steels ranged from 40 to 200 thousand pounds per square inch (ksi). The effects of notches having theoretical stress concentrations ranging from 1.3 to 6 were included in this study. General conclusions are: (1) both mechanical notches and saltwater corrosion are more damaging in high-cycle fatigue; (2) the combined effect of mechanical notches and salt water is greater than either operating independently; and (3) the high-cycle saltwater corrosion-fatigue strengths of sharply notched low and intermediate alloy steels are less than 10 ksi beyond 10-million cycles, regardless of the tensile yield strength level. Additional conclusions relative to notch root radius, corrosion characteristics of the steels, and fatigue design curves are presented. TAB

N67-21834# Iowa State Univ. of Science and Technology, Ames.
EFFECT OF OXYGEN CONTENT ON THE LIQUID METAL CORROSION OF MOLYBDENUM
Dale L. Smith, Glenn Murphy, and Ray W. Fisher Aug. 1966 91 p refs
(Contract W-7405-ENG-82)
(IS-1350) CFSTI: HC $3.00/MF $0.65

The effect of impurity oxygen on the liquid–metal corrosion of molybdenum by lead, cadmium, tin, and zinc has been determined experimentally. Static corrosion tests were conducted with electron-beam welded 0.75-in. OD by 0.035-in. wall by 2-in. long molybdenum capsules containing the four low-melting metals. The majority of the tests were conducted for 300 hours at temperatures of 700 or 800°C. The oxygen content of the liquid metals was varied from six to 10,000 parts per million. The mechanisms by which the oxygen may interact are discussed and the results of the experimental tests are explained in terms of these mechanisms. The oxygen in the lead–molybdenum system formed a lead molybdate ($PbMoO_4$) surface layer, which tended to protect the molybdenum from solution attack. Oxygen in the cadmium formed cadmium molybdate ($CdMoO_4$), which did not adhere to the surface and thus increased the corrosion slightly. Simple solution attack of molybdenum occurred with low-oxygen (8 ppM) tin; however, a compound boundary-layer formation was noted in the high-oxygen tests. The zinc diffused rapidly through the molybdenum wall leaving the capsules empty after 100 hours at 700°C. The presence of oxygen in the zinc appeared to decrease the diffusion rate of the zinc slightly. Author (NSA)

N67-21875# Marine Engineering Lab., Annapolis, Md.
METAL CORROSION IN DEEP-OCEAN ENVIRONMENTS Research and Development Report
W. L. Wheatfall Jan. 1967 31 p refs
(MEL-429/66; AD-645481) CFSTI: HC $3.00/MF $0.65

Experiments were conducted in deep-ocean environments to determine whether unusual corrosion phenomena exist at great depths that are not present in water near the surface. A total of five exposures were made at various locations in the Pacific Ocean. Two exposures were at 5640 feet, and one each at 2340, 5300, and 6780 feet. In some cases, similar tests were conducted in shallow water. Results from general corrosion tests of metals representing six typical alloy classes, and also from crevice-corrosion tests on a stainless steel and nickel alloy, revealed that, in general, there were no major differences between corrosion phenomena in deep-ocean and shallow-water environments. Variations in behavioral patterns that were observed could largely be explained on the basis of differences in oxygen content. TAB

N67-22091# General Electric Co., Cincinnati, Ohio. Nuclear Materials and Propulsion Operation.
PHYSICO-CHEMICAL STUDIES OF CLAD UO_2 IN POTENTIAL MELTDOWN ENVIRONMENTS
J. F. White *In its* High-Temp. Mater. Program 30 Sep. 1966 p 143–155 refs (See N67-22081 11-22) CFSTI: HC $3.00/MF $0.65

Results of dynamic steam corrosion tests on Zircaloy-4-clad UO_2 to determine amount of oxide, O_2-saturated metal, and unaltered metal existing at various temperatures, are reported. Isothermal steam corrosion tests on Zircaloy, Valoy, and on mild steel indicate that reactions are similar to those of 304 stainless steel. Thermal conductivity of Zircaloy-4 was measured at 1500°C and electric resistivity to 1400°C. NSA

N67-22318# California Univ., Livermore. Lawrence Radiation Lab.
FRICTION AND WEAR OF EXPLOSIVE MATERIALS
K. G. Hoge 1 Sep. 1966 28 p refs
(Contract W-7405-ENG-48)
(UCRL-50134) CFSTI: HC $3.00/MF $0.65

The frictional behavior of various explosive materials, both plastic-bonded and polycrystalline, is discussed. Test data are presented for explosive material sliding on various metallic surfaces and on itself. Surface finishes of 16, 32, and 125 μin. rms were tested. Sliding velocity was varied from 0.001 to 2500 in./min and normal pressure from 125 to about 2500 psi. Of the explosive materials tested, plastic-bonded explosives were found to have a considerably higher coefficient of friction than polycrystalline explosives. The plastic-bonded explosives also showed some viscoelastic or time-dependent effects. Some of the basic theoretical approaches to friction are discussed. Because explosives are generally quite soft, a considerable amount of wear accompanies friction. Therefore, a model for wear was formulated, which accounts for wear during short sliding distances. The contribution of friction and wear to mechanical ignition of explosives was also analyzed. Author (NSA)

N67-22325# Argonne National Lab., Ill.
CREVICE-GALVANIC CORROSION OF ALUMINUM
S. Mori, J. E. Draley, and R. E. Loess Jun. 1966 9 p refs
(Contract W-31-109-ENG-38)
(ANL-6236) CFSTI: HC $3.00/MF $0.65

In water at 50°C, localized attack occurred on 1100 Al in the crevice formed by coupling to Cu, but not outside the crevice. More severe attack occurred where Cu deposited from a $CuSO_4$ solution onto Al alloy surfaces. Pure Al was not susceptible to this type of attack. Author (NSA)

N67-22392# Kaman Aircraft Corp., Bloomfield, Conn.
FEASIBILITY STUDY OF AIR BEARING ROCKET SLED SLIPPERS Final Report, Feb. 16–Jul. 1, 1966
R. C. Meier and A. F. Smith Holloman AFB, N. Mex., Jul. 1966 123 p refs
(Contract AF 29(600)-5516)
(R-638; MDC-TR-66-110; AD-643756) CFSTI: HC $3.00/MF $0.65

A study was conducted to investigate the feasibility of applying the principle of air film lubrication to rocket sled slippers to: (1) overcome erosive oxidation and severe melting effects experienced at hypersonic speeds and (2) alleviate rail-induced vibrations. Results of the study indicate that a simple self-acting type of bearing can support a typical monorail rocket sled, without contact between the slipper and the rail, at speeds between Mach 1.5 and Mach 6. With contact eliminated, the slipper can be coated with a refractory material to prevent erosive oxidation and melting of slipper structural material. This type of air bearing slipper appears to be the most suitable for AFMDC requirements.

An externally pressurized type of slipper bearing is capable of preventing slipper-rail contact over the entire speed range of typical monorail and dual rail sleds. However, the weight and volume of the associated pressurization system are large, and are considered prohibitive for a practical design. The most critical track requirements for an application of air lubricated slippers are the vertical alignment and dimensional tolerances of the rail. Author (TAB)

N67-22452# Fairchild Stratos Corp., Bay Shore, N. Y.
APPLICATION OF A POWDER LUBRICATION SYSTEM TO A GAS TURBINE ENGINE, PART II Technical Report, Jun. 1965–Jun. 1966
Stanley Wallerstein and Lawrence Weissmann Dec. 1966 112 p refs
(Contract AF 33(615)-1331)
(AFAPL-TR-65-43, Pt. II; AD-645756) CFSTI: HC $3.00/MF $0.65

The objective of the program is to provide a powder lubrication system for a gas turbine engine. The report discusses experimental development testing of powder lubricated bearings, tested both in a specially designed bearing test rig and in a J-69 turbojet engine, modified for unfired operation with powder lubrication on a motor-driven test stand. The report summarizes the equipment, instrumentation, and experimental work carried on to attain quantitative and performance data on engine bearings as well as the powder lubrication delivery and exhaust system. Author (TAB)

N67-22476# Atomic Energy of Canada, Ltd., Chalk River (Ontario). Nuclear Lab.
WEAR RATES OF METALS AND OXIDES IN 80° AND 160°F HIGH PURITY WATER
J. T. Dunn Aug. 1966 79 p refs
(AECL-2602) CFSTI: HC $3.00/MF $0.65

The wear rates of 157 material combinations were determined as 3/4 in. i.d. × 3/4 in. long sleeve bearings in high purity pH 7 water under loads of 20 to 250 lbs at speeds of 20 to 280 rev/min for periods of 4 to 14 days. These wear results were reported as a volume rate of wear, called specific wear, which can be used directly with the load, size, and expected life of sliding contacts to predict the approximate depth of wear. The specific wear of materials evaluated ranged from 0.3 to 12,000 and the best materials (those with low specific wear) were the hard oxides on zirconium alloys and on a proprietary nickel–tin–bismuth alloy. In over half of all tests run the wear rates decreased with increasing sliding distance. To numerically describe this wear-in behavior a wear-in factor was defined which indicates the rate of change of wear rate with distance. This wear-in effect was a function of speed and load and it was felt to be due to the gradual build-up of hydrodynamic thin film lubrication in the bearing wear scar. Author

N67-22787# Royal Aircraft Establishment, Farnborough (England).
THE EFFECT OF HUMIDITY ON SOLID LUBRICANT FILMS
Edna Kay Mar. 1965 19 p refs
(RAE-TR-65047) CFSTI: HC $3.00/MF $0.65

The friction of thin rubbed films of graphite, molybdenum disulphide, tungsten disulphide and metal-free phthalocyanine on metal substrates increased markedly with the relative humidity of the surrounding atmosphere. Film endurance is also impaired, but the addition of 10% graphite of MoS_2 produces a marked improvement in performance over that obtained with MoS_2 alone. Although the friction of MoS_2 sliding on itself increases slightly with humidity, the nature of the metallic substrate is a major factor in thin film performance at high humidity. Author

N67-22842*# Aerojet-General Nucleonics, San Ramon, Calif.
AEROJET-GENERAL NUCLEONICS MERCURY CORROSION LOOP PUMP
J. H. Ralphs and E. F. McDaniel 17 Feb. 1964 33 p
(NASA-CR-72201; TM-390-64-8-204) CFSTI: HC $3.00/MF $0.65 CSCL 13K

Six pumps were fabricated for the Mercury Corrosion Loop Testing Program. The wetted parts of the various pumps were made of different materials: Type 316 stainless steel in the prototype, Haynes Alloy 25 in the next four pumps, and 9% chromium–1% molybdenum (9Cr–1Mo) alloy steel in the sixth. The stainless steel pump was tested in a non-boiling mercury pump-testing loop to establish the feasibility of the design and to determine whether any changes were required before use of the pumps in the boiling mercury loops. The Haynes 25 pumps were tested in the pump test loop and also were operated in the mercury corrosion loops. Through testing and loop operation, a type of pump was evolved which was capable of supplying 1200 lb/hr of mercury at an output pressure of 450 psig. The principal deficiency found in the pumps was the short lifetime of the mechanical seal separating the inert gas space above the mercury from the atmosphere. The service life of these seals proved to be about 200 operating hours. Author

N67-22860* Aerojet-General Nucleonics, San Ramon, Calif.
MERCURY CORROSION AND EVALUATION OF CORROSION PRODUCT SEPARATORS IN 9 Cr-1 Mo BOILING THERMAL CONVECTION LOOPS
M. F. Parkman 18 Feb. 1964 69 p refs
(NASA-CR-72200; TM-390-64-4-205) CFSTI: $3.00 CSCL 18N

Three 9Cr–1Mo boiling thermal convection loops were operated for 1000 hrs at 1075°F boiling-condensing, 1250°F superheat, and 500°F subcooled temperatures. A similar loop was operated at 700°F boiling-condensing, 800°F superheater, and 500°F subcooled temperatures. Flow rate in all cases was 7.2 lbs/hr, equivalent to 2.0 lbs/hr-in^2 of condenser surfaces. Corrosion product separators consisting of a magnet section, a columbium wool section, and an iron wool section were included in the liquid leg of two of the 1075°F loops. Results are discussed. Corrosion products were found in the separators; the trapping mechanism appeared to be simply one of presentation of a large surface and a long residential time. No preferential trapping by either wool was noted. The mercury was subcooled to 500°F before entering the traps. More than half of the recovered corrosion products was deposited in the region ahead of the trap; some occurred after the trap, but was not recovered. Preliminary boiling stability tests were conducted in full scale glass models of the loop and in one of the 9Cr-1Mo loops. Author

N67-22880*# Aerojet-General Corp., Azusa, Calif.
EVALUATION OF METHODS TO REMOVE DECOMPOSED MIX-4P3E FROM 9Cr-Mo STEEL
F. H. Cassidy 2 Aug. 1965 10 p refs
(NASA-CR-72223; TM-4923-65-310) CFSTI: HC $3.00/MF $0.65 CSCL 07B

The evaluation of selected candidate procedures for removal of thermally decomposed mis-4P3E is reported. Oxidation of the residue by 1300°F air exposure, followed by pickling, successfully removed surface adherent residue. The procedure consisted of twice performing the multi-step cycle: (1) air exposure at 1300°F for 1/2 hour; (2) three-step clean with Turco Products, Inc., fluids Turco 4931, then Turco 4338C and finally Turco 4931. A yellowish surface discoloration of the specimen resulted from cleaning. Further evaluation is required to determine if this surface condition represents an unacceptable mercury non-wetting condition. Author

N67-22890* Aerojet-General Corp., Azusa, Calif.
EVALUATION OF ALTERNATE LUBRICANT/COOLANT FLUIDS FOR SNAP-8
P. I. Wood, J. M. Carter, and F. H. Cassidy 9 Sep. 1965 51 p refs
(NASA-CR-72219; TM-4921-65-1-327) CFSTI: $3.00 CSCL 18J

A study of alternate lubricant/coolant fluids for SNAP-8 was made to update the evaluation which led to the selection of polyphenyl ether (4P3E) some two years prior. Ten candidate fluids were evaluated; of these, the four most promising fluids were compared in as much depth as available data permitted. Properties of the fluids are tabulated in an appendix. Author

N67-22906# Societe d'Etudes, de Recherches et d'Applications pour l'Industrie, Brussels (Belgium).
CORROSION OF STAINLESS STEELS IN HIGH TEMPERATURE WATER AND STEAM
M. Warzee, W. R. Ruston, P. de Dorlodot, J. Hennaut, and J.-Ph. Berge (EURATOM) Brussels, EURATOM, Dec. 1966 14 p refs Presented at the 3rd Intern. Congr. on Metallic Corrosion Moscow, 16–25 May 1966
(Contract EURATOM-089-62-7 RDB)
(EUR-2857.e; EURAEC-1665) CFSTI: HC $3.00/MF $0.65

The corrosion of stainless steels in steam increases regularly between 200 and 300°C. This is not so in water: there, corrosion as function of temperature shows a marked maximum around 250°C for AISI 410 steel. For AISI 304 steel the maximum, which was not actually observed, must lie at a lower temperature. The quantity of dissolved metal is responsible for the maximum. It was shown that magnetite crystals grow out of the solution and that this redeposition may cause underestimation of corrosion values obtained in static autoclave tests. The observed phenomenon is of great technical significance because the crystallization of magnetite from solution may cause mass transfer from cooler to hotter parts in nuclear reactors cooled with water and operating around 300°C. Author

N67-22979# Oesterreichische Studiengesellschaft fuer Atomenergie G.m.b.H., Seibersdorf. Inst. fuer Reaktorentwicklung.
PROBLEMS OF A SODIUM-LOOP DESIGNED TO OPERATE AT TEMPERATURES UP TO 800°C
E. Matyas, G. Rajakovics, and N. Schwarz [1966] 17 p Presented at the Symp. on Alkali-Metal Coolants Corrosion Studies and Systems Operating Experience, Vienna, 28 Nov. 1966 Prepared in cooperation with Gebrueder Boehler and Co.
(SGAE-RE-61966) CFSTI: HC $3.00/MF $0.65

The problem of corrosion resistance in a sodium loop designed to operate at 800°C is discussed. The possibility of developing new steels and alloys with better resistance is mentioned, and heat transfer studies are suggested to support component development with the aim of increasing economy. For this purpose very small sensing devices will have to be developed for operation at elevated temperatures. Details are given on the components and layout of the sodium rig, mixing chambers with bypass flow scheme, heat exchanger, corrosion test section, and auxiliary oil system. L.E.W.

N67-23102# Naval Research Lab., Washington, D. C.
CORROSION OF METALS IN TROPICAL ENVIRONMENTS. PART 7: COPPER AND COPPER ALLOYS—SIXTEEN YEARS' EXPOSURE
C. R. Southwell, C. W. Hummer, Jr., and A. L. Alexander 28 Oct. 1966 34 p refs
(NRL-6452; AD-644930) CFSTI: HC $3.00/MF $0.65

The corrosion of copper and nine wrought copper alloys is reported for exposures in five tropical environments for one, two, four, eight, and sixteen years. Weight loss, pitting, and change in tensile strength were measured to evaluate corrosion resistance. Higher corrosion rates are shown for tropical sea water immersion and tropical marine atmosphere than similar exposures in temperate climates. Of the various alloys studied, 5% Al bronze showed the highest general corrosion resistance; its 16-year losses in sea water were only 1/5 that of copper. Copper and the high-copper alloys were resistant to all environments and generally had decreasing corrosion rates with time of exposure. Tensile tests revealed heavy dezincification in the lower-copper brasses when exposed in marine environments, and for two of the brasses in fresh water immersion. As a result of the decreasing corrosion rates or dezincification, antifouling properties of copper alloys decreased with time of exposure. All were moderately to heavily fouled after 16 years in sea water. Galvanic effects were pronounced in tropical sea water. The corrosion of copper alloys was accelerated appreciably by contact with stainless steel (316) of 1/7 their area, while similar carbon steel strips gave effective cathodic protection of plates of brass and bronze over the long term. Author (TAB)

N67-23182# Virginia Polytechnic Inst., Blacksburg. Dept. of Metals and Ceramic Engineering.
THE RELATIONSHIP OF NITROGEN CONTENT OF AUSTENITIC STAINLESS STEELS TO STRESS CORROSION Quarterly Report, 1 Jul.–30 Sep. 1966
Thomas B. Cox 30 Sep. 1966 18 p refs
(Contract AT(40-1)-3208)
(EURAEC-1755; QR-438-9) CFSTI: HC $3.00/MF $0.65

As part of an investigation to determine relationship between N content of austenitic stainless steels and susceptibility to stress-corrosion cracking, experiments were conducted in which the solubility of N_2 in AISI Types 304 and 308 stainless steel wires was determined. NSA

N67-23186# Societe d'Etudes, de Recherches et d'Applications pour l'Industrie, Brussels (Belgium).
STUDIES OF STEEL CORROSION IN HIGH TEMPERATURE WATER AND STEAM
30 Oct. 1966 89 p Transl. into ENGLISH from French
(Contract EURATOM-087-66-TEEB RD)
(EUR-3304; EURAEC-1744; QR-16) CFSTI: HC $3.00/MF $0.65

The study of the recrystallization conditions of various grades of milled stainless steels was continued. It was found that Uranus 30 steel offers good behavior under oxidation, after surface treatment, at temperatures at which standard 18-10 steels tend to deteriorate. The study of grain size, with or without prior selective oxidation treatment, was initiated on various grades of stainless steels. The initial results, for oxidation pretreatment at 800°C, indicate definite influence of the grain size under these conditions. The effect is quantitatively inadequate, however. Long-duration tests in superheated steam at 500°C on AISI 304 L steel show that the work-hardening depth obtained by grinding is insufficient to guarantee satisfactory steel behavior. Tests in superheated steam at 500°C with 20 ppM oxygen added do not show any weight differences from the tests carried out without oxygen. In the tests with oxygen added, the oxide skin formed on a surface work-hardened 304 steel remains of the spinel type whereas that formed on electrolytically polished steel consists primarily of α-Fe_2O_3. NSA

N67-23248# Advisory Group for Aerospace Research and Development, Paris (France).
CORROSION OF AIRCRAFT
H. G. Cole, ed. Apr. 1966 55 p Summaries and Discussions of Papers Presented at 22d Meeting of AGARD Struct. and Mater. Panel, Delft, Netherlands, 19–20 Apr. 1966
(AGARD-540) CFSTI: HC $3.00/MF $0.65

Abstracted data are presented from a symposium on aircraft corrosion which was divided into the following sections: (1) corrosion in service, (2) design to avoid corrosion, (3) inspection in service, and (4) damage and assessment. Summaries of the panel discussions following each conference presentation are also included. A.G.O.

N67-23277* National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
A CASE HISTORY OF TITANIUM STRESS CORROSION IN NITROGEN TETROXIDE
Robert E. Johnson, George F. Kappelt (Bell Aerosystems Co., Buffalo), and Larry J. Korb (North American Aviation, Inc., Downey) [1966] 20 p Presented at the 1966 Natl. Metals Congr., Chicago
(NASA-TM-X-59615) CSCL 11F

An investigation of the incompatibility of titanium in certain grades of nitrogen tetroxide is discussed. The methodology used in its resolution points out some of the dangers associated with compatibility testing. The methodology also presents some of the difficulties associated with coordinating an investigation involving many contractors and agencies. The techniques employed in this investigation are described in considerable detail for the benefit of investigators with similar problems. Author

N67-23301*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OPERATION OF HYDRODYNAMIC JOURNAL BEARINGS IN SODIUM AT TEMPERATURES TO 800°F AND SPEEDS TO 12,000 RPM

Fredrick T. Schuller, William J. Anderson, and Zolton Nemeth Washington, NASA, Apr. 1967 31 p refs

(NASA-TN-D-3928) CFSTI: HC$3.00/MF$0.65 CSCL 13I

A series of experiments was conducted with 1.5-inch-diameter hydrodynamic journal bearings in liquid sodium at 500° and 800°F at speeds to 12,000 rpm with unit loads to 31.1 pounds per square inch. Bearings of five different configurations were tested. Tilting-pad bearings were the most stable, followed in order by (1) a plain cylindrical bearing with a herringbone-groove journal, (2) a three-axial-groove cylindrical bearing, pressure fed from an axial shaft pump through a hole in the journal, and (3) three- and two-axial-groove cylindrical bearings. Stellite Star J material mated with Hastelloy X, titanium carbide (K184B), or Inconel had the best wear and seizure properties. Also titanium carbide (K184B) mated with a molybdenum-0.5 percent titanium alloy showed excellent promise. Surface damage to the tilting-pad-bearing pivots was observed in some tests, even after short runs at light loads. Existing theory is adequate for predicting the onset of instability in circular, axially grooved bearings. Author

N67-23311*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STUDIES OF ROLLING-ELEMENT LUBRICATION AND FATIGUE LIFE IN A REDUCED PRESSURE ENVIRONMENT

David W. Reichard, Richard J. Parker, and Erwin V. Zaretsky Washington, NASA, 1967 20 p refs Presented at the Ann. Meeting of the Am. Soc. of Lubrication Engr., Toronto, 1–4 May 1967

(NASA-TM-X-52287) CFSTI: HC$3.00/MF$0.65 CSCL 13I

Fatigue tests were conducted in a modified five-ball fatigue tester on SAE 52100 steel ball specimens, at atmospheric pressure and at the approximate lubricant vapor pressure with two different lubrication methods, using a super-refined naphthenic mineral oil as the lubricant. Additional tests were conducted with AISI M-50 ball specimens with polyphenyl ether lubricants. Differences in fatigue life, deformation, and wear with the mineral oil lubricant were insignificant regardless of the ambient pressure environment or lubrication method employed. Polyphenyl ether lubricants exhibited large amounts of wear both at atmospheric and reduced pressures indicating a lack of an elastohydrodynamic film with this lubricant under the stresses and sliding velocities present in the five-ball fatigue tester. Author

N67-23312*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE BEHAVIOR OF LUBRICATION SYSTEM COMPONENTS IN A VACUUM ENVIRONMENT

Donald H. Buckley Washington, NASA, 1967 27 p refs Presented at the 2d Aerospace Mech. Symp., Santa Clara, Calif., 4–5 May 1967

(NASA-TM-X-52284) CFSTI: HC$3.00/MF$0.65 CSCL 11H

Evaporation experiments were conducted with various fluids, greases, inorganic compounds, and soft metals to determine the vacuum environment effect on evaporation behavior. Friction, adhesion, and wear experiments were conducted with the various materials used in lubrication systems to determine the vacuum environment effect on friction, wear, and adhesion. The results indicated that while relatively high rates of evaporation may be obtained for conventional oil and grease lubricants these materials may be effectively utilized if concepts such as molecular flow seals are used to reduce evaporative losses. Further, for prolonged exposure to vacuum environment, many inorganic compounds and soft metal films have potential usefulness. In addition to evaporation losses, concern must be provided for the type of lubricant that is used. With conventional lubricants degassing of the fluids can present a problem. The results of sliding friction experiments in a vacuum environment indicate that there are basic metallic structures which have markedly superior friction, wear, and less tendency to adhere than now conventionally used bearing materials. Selective alloying of these metallic structures could be effectively used to prepare alloys specifically designed for use in lubrication mechanisms. Author

N67-23348# Naval Research Lab., Washington, D. C.

DRY-FILM LUBRICANTS FROM MOLYBDENUM DISULFIDE BONDED WITH MICROFIBROUS BOEHMITE

V. G. FitzSimmons and W. A. Zisman 22 Dec. 1966 25 p refs

(NRL-6468; AD-645889) CFSTI: HC$3.00/MF$0.65

Binders that have been tried for powdered lamellar dry lubricants have short-comings such as hindering the realignment of the lubricant particles or encapsulating the lubricant, making a wearing-in process necessary. A microfibrous form of colloidal alumina (boehmite) is shown to act as a superior nonencapsulating binder for molybdenum disulfide in the formation of dry lubricant films. Such films exhibit lower coefficients of friction than have been reported for molybdenum disulfide or graphite films bonded with any other material. These new lubricating coatings have good load-carrying ability and durability at any temperature below the decomposition temperature of molybdenum disulfide (700 F). Optimum performance of these boehmite-bonded films is obtained when (a) the ratio of fibrillar boehmite to MoS2 is near 0.20, (b) the film is 0.2 to 0.5 mil thick, (c) the substrate is hard and highly polished, and (d) the film is applied as an alkaline dispersion (pH = 10) and then dehydrated by baking at 550 F. Author (TAB)

N67-23380# Naval Radiological Defense Lab., San Francisco, Calif.

MEASUREMENT OF SEAWATER CORROSION OF SNAP CONTAINER ALLOYS USING RADIOACTIVE TRACER TECHNIQUES

Don A. Kubose, Ming G. Lai, Harry A. Goya, and Herman I. Cordova 3 Jan. 1967 45 p refs

(Contract AT(49-5)-2084)

(USNRDL-TR-1092; AD-645553) CFSTI: HC$3.00/MF$0.65

Corrosion rates of Haynes 25, Hastelloy C and Hastelloy N in seawater were measured using two radioactive tracer techniques. These techniques involved (1) measurement of the radioactivity leached into seawater from radioactive alloy specimens and (2) performing neutron activation analysis of corrosion products in seawater in which inactive alloy specimens had been placed. The second technique was used to determine whether the gamma recoil from the thermal neutron activation of the alloys in the first technique had affected their corrosion properties. It was found that the gamma recoil from neutron activation had only a small effect on the corrosion rate of the alloys. The average corrosion rates obtained for Hastelloy C and Hastelloy N were 0.00005 mil per year and 0.0001 mil per year, respectively. No appreciable differential leaching of the cobalt, nickel and chromium components of these alloys was observed. The results obtained for Haynes 25 indicated differential leaching had occurred. The corrosion rate calculated from the amount of cobalt released was 0.000001 mil per year while that calculated from the amount of chromium released was 0.00001 mil per year. Author (TAB)

N67-23594# Brookhaven National Lab., Upton, N. Y.
CORROSION BY THE ALKALI METALS
J. R. Weeks, C. J. Klamut, and D. H. Gurinsky [1966] 13 p refs Presented at the IAEA Symp. on Alkali Metal Coolants, Corrosion Studies, and System Operating Experience, Vienna
(Contract AT(30-2)-GEN-16)
(BNL-10800; CONF-661110-7) CFSTI: HC$3.00/MF$0.65

A review is presented of the state of the art of corrosion testing of materials by the alkali metals, the models proposed to explain the observed corrosion results, and the status of materials selection for application in alkali metal-cooled systems. Studies and the liquid metal-cooled reactors in operation demonstrate that stainless steels can be considered for structural and cladding applications below 650°C. Corrosion models are reviewed and their inability to explain all the experimental observations discussed. An alternate model is proposed which qualitatively is in agreement with experimental observations. In this model, the rate controlling step is either the surface reaction of Fe with "available oxygen" (dissolved Na_2O) to form an Fe–O–Na complex or the rate at which "available oxygen" can reach the surface to form the complex; which process is rate controlling depends on the temperature, Na velocity, and oxygen concentration in the Na. The solution chemistry of O_2, C, and alkali metal-oxygen-transition metal complexes dissolved in the alkali metals is reviewed. "Molecular" complexes appear unlikely to exist in solution in the alkali metals, although the thermodynamic tendencies for them to form suggest that stable bonds exist in solution between O_2, the transition, and the alkali metals. The insolubility of C in "oxygen-free" Na indicates that C transfer may be associated with O_2 in Na down to very low oxygen levels, although experimental data do not generally confirm this postulate. Corrosion of refractory metals by boiling alkali metals at temperatures above 1000°C is markedly affected by impurities in either the liquid or refractory metal; the addition of Ti, Zr, or Hf as "getters" to the refractory alloys and proper heat treatment to react the "getter" addition with O_2, N_2, C, and H_2 in the alloys are required to prevent their corrosion by the alkali metals at these temperatures. Author (NSA)

N67-23689# Metallgesellschaft A. G., Frankfurt am Main (West Germany).
FURTHER DEVELOPMENT OF THE $ZrBn_3Sn1$ ZIRCONIUM ALLOY, WITH REFERENCE TO ITS USE FOR CLADDING IN WATER-COOLED REACTORS Final Report No. 2
K. Drefahl, H. Richter, and W. Ruckdechel 23 Jun. 1966 94 p refs Transl. into ENGLISH from German
(Contract EURATOM-019-63-11 TEED)
(EURAEC-1725) CFSTI: HC$3.00/MF$0.65

Work was carried out to improve the properties of the Zr–Nb–Sn alloy by changing its tin content and by adding other alloying elements (Cu, Fe, Cr, Ge, V, Sb, and Te) constituting up to 0.5% of total weight. Corrosion behavior in steam at 400 and 450°C, together with mechanical properties at 450°C, was given special prominence in the investigations. A start was made by investigating the corrosion behavior of 51 alloys. Eleven Zr–Nb alloys to which other elements were added were selected for more detailed investigation. Results showed that the corrosion behavior of the Zr–Nb–Sn alloy in steam heated to 400°C can only be improved to a relatively small extent by changing its composition. A reduction in Sn content induced a considerable improvement in corrosion properties in steam heated to 450°C. In particular, the addition of Cu, Fe, Cr, or Sb was helpful at these high corrosion temperatures. The percentage of H_2 absorption of ternary Zr–Nb alloys with Fe, Cr, or Sb was found to be particularly low. Unfortunately, a reduction in tin content reduces strength and has an adverse effect on creep behavior. The influence of other additional alloying elements is difficult to ascertain, since the Nb content of the various alloys is varied to give roughly the same absorption cross section for thermal neutrons. However, it appears that Sb and V additives give higher short-time strengths than Cu, Fe, and Cr additives. Sb and V also have a good effect on creep behavior. The alloys with 1% Sn (by weight) and Fe additives, which show up particularly well in creep tests, failed at high corrosion temperatures. The Zr–Nb–Sb alloy had relatively high elongation values even after corrosion, while alloys containing Fe showed a sharp elongation value drop in steam at 450°C if they had a Sn content of as little as 0.3%. An increase in Sn content intensifies corrosion and reduces elongation still further. Author (NSA)

N67-23732# Mechanical Technology, Inc., Latham, N. Y.
EXPERIMENTAL TEST AND EVALUATION OF A GAS-BEARING CYCLE TURBOCOMPRESSOR Progress Report, 20 Jun.–1 Sep. 1966
J. S. Meacher 15 Dec. 1966 262 p
(Contract AT(30-1)-3237)
(NYO-3237-7) CFSTI: HC$3.00/MF$0.65

Feasibility of, and problem areas associated with, the application of gas-lubricated bearings to closed-system gas-turbine machinery are discussed. A Brayton cycle gas generator (turbocompressor) utilizing self-acting gas bearings was designed, built, and is being tested. Self-sustained closed-loop operation of the turbocompressor, using its own cycle gas as the bearing lubricant, was achieved. The turbocompressor has been successfully operated, with nitrogen at 1300°F (design point) and 1400°F (design maximum) turbine inlet temperature and at a speed of 24,000 rpm. The turbocompressor has also been operated under "no-load" and "load" conditions in argon at turbine inlet temperatures up to 1355°F. Tests were made to determine the dynamic response of the turbocompressor-loop system to transients in loop pressure level, compressor bleed flow, and throttle valve setting. Plots of response data are presented for these transient tests and for heater power and compressor inlet temperature transient tests. A number of steady-state test points were taken with the turbocompressor operating at 30 psia compressor inlet pressure (the design value is 15 psia). Additional turbocompressor performance test data were secured using argon for the loop working fluid and bearing lubricant gas. The maximum average turbine inlet temperature during these argon runs was 1355°F. A new hydrostatic-hydrodynamic thrust bearing has been designed, fabricated, and installed on the turbocompressor. NSA

N67-23876# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
OILS FOR GAS-TURBINE INSTALLATIONS
B. V. Losikov and A. D. Fat'yanov 25 Apr. 1966 16 p ref Transl. into ENGLISH from Khim. i Tekhnol. Topliv i Masel (Moscow), no. 3, 1964 p 58–62
(FTD-TT-65-1843; TT-66-62442; AD-640307)

Conclusions: There has been shown the possibility of considerable improvement in the stability of transformer oil at 170 and 200°C with the additive of ionol (0.2–0.7%). It was established that the addition of 1% of sovol to transformer oil raises its antiwear properties to the level of the antiwear properties of the oil MK-22, while the presence of sovol in the oil does not lessen its antioxidation stability and does not lower its receptability to ionol. Tests of transformer oil which contains ionol and sovol on a fullsized gas-turbine installation confirmed completely the possibility of dependable working on the equipment with the indicated oil. Oil for gas turbines containing additives of ionol and sovol at the present time is being put out in accordance with GOST 10289-62. Author (TAB)

N67-23893# Atomic Energy Commission, Washington, D. C.
PLAIN AND ANTIFRICTION BEARINGS FOR EXTREME REACTOR CONDITIONS, PART II
F. Helfrich [1964] 26 p refs Transl. into ENGLISH from Die Atomwirtschaft (Germany), no. 9, 1964 p 168–174
(AEC-TR-6839, Pt. 2)

To satisfy reactor operational requirements for safety and elimination of maintenance, experience is obtained with bearings

under extreme reactor conditions. By experimental efforts in Jülich for the AVR high-temperature reactor and by cooperation with the Dragon project in Great Britain, BBC/Krupp was first able to work out design data for bearings in extremely dry He atmosphere. All tests showed the importance of MoS_2 lubricant in reducing friction and wear. The use of grease in ball bearings is also reported. Author (NSA)

N67-23955# Bureau of Mines, Albany, Oreg.
THORIUM ALLOY SYSTEMS
Hal J. Kelly and Stephen A. O'Hare *In its* Met. Progr. Rept. 30 Jun. 1966 p 13–16 ref (See N67-23953 12-15)

The alloys were studied in two groups, based on the thoria particle size. The first group of alloys was composed of submicron-size thoria additions and was evaluated for possible high-temperature strengthening; the composition range of these alloys was from 1 to 5 weight-percent thoria. The second group consisted of thorium with micron-size thoria particles. These alloys had a composition range from 15 to 50 volume-percent thoria and were used to simulate reactor fuel. The effect of thoria addition and temperature was noted on tensile properties from 400°C to 800°C, hot hardness from 20°C to 850°C, and electric resistivity at ambient temperature. While temperature affected both hardness and tensile strength, the thoria content did not; thoria did affect the electric resistance. Also conducted was a study of cermets containing 15 to 50 volume-percent thoria in a thorium matrix during which tensile properties and electric resistance were measured at room temperature and corrosion resistance at 150°C. K.W.

N67-24043# Marine Engineering Lab., Annapolis, Md.
Ti-6Al-2Cb-1Ta-0.8Mo TITANIUM ALLOY AS A STRUCTURAL MATERIAL FOR MARINE APPLICATIONS
J. L. Cavallaro Jan. 1967 49 p refs
(MEL-506/66; AD-645937) CFSTI: HC$3.00/MF$0.65

A sea-water, stress-corrosion-resistant compositional variation of Ti-7Al-2Cb-1Ta, Ti-6Al-2Cb-1Ta-0.8Mo, has been developed and evaluated as a candidate pressure-hull material. Thick plate produced from pilot heats and production heats of the alloy were found to have good toughness and to be resistant to sea-water stress corrosion and corrosion fatigue. Properties of weldments of the alloy were found to be as good as the base metal and free from sea-water stress corrosion in the as-welded and stress-relieved conditions. A production heat of Ti-6Al-2Cb-1Ta-0.8Mo was evaluated in tension, compression, Charpy v-notch impact, sea-water stress corrosion, low-cycle fatigue, high-cycle fatigue, Bauschinger effect, and stress relaxation. The alloy has a tensile yield strength of 100 ksi in 1-inch thickness and 96 ksi in 2.5-inch thickness. Preliminary data from processing and heat treatment investigations in progress indicate the strength can be raised approximately 5 ksi. The Ti-6Al-2Cb-1Ta-0.8Mo alloy is considered suitable for use as a weldable, high-toughness structural metal for marine applications. Author (TAB)

N67-24310 Furukawa Electric Co., Ltd., Tokyo (Japan). Central Research Lab.
STUDIES ON WORKABILITY, HEAT TREATMENT CHARACTERISTICS AND CORROSION RESISTANCE FOR PRESSURIZED WATER OF Zr-1% Mo-1% Cr AND Zr-1% Mo-1% Ni ALLOYS
Shigeo Aoki Tokyo, Japan Atomic Energy Res. Inst., Jan. 1966 16 p refs Transl. into ENGLISH from J. Japan Inst. Metals (Sendai), v. 28, no. 1, Feb. 1964 p 22–27 revised
(NSJ-TR-24; Rev.) CFSTI: $3.00

The workability, effect of the heat treatment on the mechanical properties and the micro-structures, and corrosion resistance for pressurized water of Zr–1%Mo–1%Cr and Zr–1%Mo–1%Ni alloys which resulted from previous works have been investigated in comparison with Zircaloy-2. The results obtained are summarized as follows. (1) The percent reductions of the alloys drop-forged in the temperature range of 600°≈900°C were nearly the same as those of Zircaloy-2. (2) Remarkable hardening occurred in both alloys when they were quenched from β phase; (3) The optimum procedures of the heat treatment to obtain the favourable mechanical properties of Zr–1%Mo–1%Cr and Zr–1%Mo–1%Ni alloys were to temper them at 750°C and 600°C for 100 min respectively, after quenching from 950°C in β phase; and (4) The weight gain of Zr–1% Mo–1% Cr alloy over the corrosion period of 500 hr in pure water at 300°C under pressure of 80 kg/cm^2

N67-24365# Battelle Memorial Inst., Columbus, Ohio.
FORMATION OF ALKALI IRON SULFATES AND OTHER COMPOUNDS CAUSING CORROSION IN BOILERS AND GAS TURBINES Summary Report, Jul. 1–Dec. 31, 1966
31 Dec. 1966 51 p refs
(Contract NObs-94516)
(SR-1; AD-647777) CFSTI: HC$3.00/MF$0.65

Sulfates, formed by the interaction of SO3, SO2, and O2 in flue gas with alkalies from the fuel and iron oxides are invariably found in corrosion areas. Alkali sulfates, such as Na2SO4, are formed rapidly. Iron sulfates, both FeSO4 and Fe2(SO4)3, can also occur, although the thermodynamics are unfavorable in a low-SO3 atmosphere. Alkali sulfates and iron sulfates can react to form alkali iron trisulfates, for example Na3Fe(SO4)3. These are highly corrosive but their formation also requires more SO3 than is found in bulk flue gas. Recent work has shown that the high SO3 level needed to produce these complex sulfates can be provided by catalysis at surfaces, even though the SO3 is too low in the bulk gas stream. Studies reported here show quantitatively that the SO3 concentration immediately next to an Fe3O3 surface can be many times higher than in the bulk stream of gas, and can be ample to provide the SO3 necessary to form the trisulfates. Author (TAB)

N67-24459*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
FRICTION CHARACTERISTICS OF SINGLE-CRYSTAL AND POLYCRYSTALLINE RHENIUM IN VACUUM (10^{-11} TORR)
Donald H. Buckley Washington, NASA, May 1967 16 p refs
(NASA-TN-D-3955) CFSTI: HC$3.00/MF$0.65 CSCL 11F

An investigation was conducted in vacuum to determine the friction characteristics of rhenium in its single-crystal and polycrystalline forms. Experiments were conducted with a hemispherical rider sliding on a flat disk at 0.001 to 700 centimeters per second at ambient pressures to 10^{-11} torr. Polycrystalline rhenium was examined sliding on itself at temperatures to 680°C and loads to 2500 grams. Single-crystal experiments were conducted at 20°C for loads to 1000 grams with the basal (001) plane sliding in the $[11\bar{2}0]$ and $[10\bar{1}0]$ directions and the prismatic plane $(10\bar{1}0)$ sliding in the $[11\bar{2}0]$ and [0001] directions on polycrystalline rhenium. The results of this investigation indicate that the friction characteristics of rhenium are highly dependent on its anisotropic nature. Comparative friction experiments with tantalum indicate that cubic tantalum exhibits high friction coefficients and welding in vacuum. With rhenium, no evidence of cold welding was observed. Friction data for rhenium correlate with the relation established for lattice parameters and the friction coefficients of hexagonal metals. The marked work-hardening characteristics of rhenium influenced both single-crystal and polycrystalline friction. Author

N67-24474*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WEAR AND FRICTION OF IMPREGNATED MECHANICAL CARBONS AT TEMPERATURES TO 1400°F (760°C) IN AIR OR NITROGEN
Thomas N. Strom, Gordon P. Allen, and Robert L. Johnson Washington, NASA, May 1967 19 p refs
(NASA-TT-D-3958) CFSTI: HC$3.00/MF$0.65 CSCL 11B

Friction and wear tests were conducted with some impregnated mechanical carbons to determine their performance at high temperatures. Loaded hemispherically tipped carbon riders were in

sliding contact with rotating chromium-plated disks in air or in nitrogen. A surface speed of 10,000 feet per minute (50.8 m/sec), a load of 1000 grams, and temperatures to 1400°F (760°C) were used. Results indicate that impregnated mechanical carbons can function satisfactorily in air to 1200°F (649°C). Performance of the materials was generally better in nitrogen than in air at 1200°F (649°C). Oxidation plays an important role in friction and wear behavior at high temperatures. Author

N67-24561# Union Carbide Nuclear Co., Oak Ridge, Tenn.
A METHOD OF USING A POROUS MEDIUM TO DETERMINE THE COEFFICIENTS OF VISCOSITY FOR BROMINE TRIFLUORIDE
T. W. Selby 13 Jan. 1967 35 p refs
(Contract W-7405-ENG-26)
(K-1680) CFSTI: HC $3.00/MF $0.65

Experimental evaluations have been made of a porous-medium method for determining relative coefficients of viscosity for corrosive and noncorrosive gases. The apparatus and operating procedure are described in detail. Measurements of the coefficients of viscosity for argon were made over the temperature range of 35° to 200°C and are given by the equation, η, micropoise $=22.14\sqrt{T,°K}-157.9$. Measurements of the coefficients of viscosity for bromine trifluoride were made over the temperature range of 130° to 200°C and are given by the equation, η, micropoise $=21.33\sqrt{T,°K}-230.2$. From these data, the force constants for the Lennard–Jones (6–12) potential for bromine trifluoride were calculated to be, $\epsilon/k=595$K and $\sigma=4.04$ A. Author (NSA)

N67-24591 Societe d'Etudes, de Recherches et d'Applications poor l'Industrie, Brussels (Belgium).
INFLUENCE OF SURFACE TREATMENT ON THE CORROSION OF CARBON STEEL AND STAINLESS STEEL IN HIGH TEMPERATURE WATER AND STEAM. SECOND PART: EVALUATION OF CORROSION BY MEASURING HYDROGEN IN REACTION [INFLUENCE DU TRAITEMENT DE SURFACE SUR LA CORROSION D'ACIERS AU CARBONE ET INOXYDABLE DANS L'EAU ET LA VAPEUR A HAUTE TEMPERATURE. DEUXIEME PARTIE: EVALUATION DE LA CORROSION PAR LA MESURE DE L'HYDROGENE DANS LA REACTION]
C. Sonnen and M. Warzee Brussels, EURATOM, Feb. 1967 35 p refs In FRENCH; ENGLISH summary
(Contract EURATOM-089-62-7 RDB)
(EURAEC-1764; EUR-1735.f, Vol. II) CFSTI: HC $3.00/MF $0.65

The method described herein allows the study of the reaction kinetics of metals and alloys of the iron family, in high temperature water and steam under mechanical stress. The possibilities and application limitations of this method are defined on basis of results obtained with a pressure vessel steel and with an austenitic stainless steel (AISI 304L) oxidized in water and steam at temperatures ranging between 300° and 450°C. Curves giving the evolution of total corrosion and of the rate of corrosion confirm the influence of the surface state previously established by tests in autoclaves. The effects of this influence appear from the first moments of the reaction and generally remain in the course of long duration tests. Author

N67-24636*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
PROCEDURES FOR EXTERNALLY LOADING AND CORROSION TESTING STRESS CORROSION SPECIMENS
T. S. Humphries 29 Jun. 1966 37 p refs
(NASA-TM-X-53483) CFSTI: HC $3.00/MF $0.65 CSCL 11F

The procedures for externally loading various types of stress corrosion specimens and a description of the test specimens are presented. An accelerated corrosion test method which consists of alternate immersion in a 3-1/2 percent sodium chloride solution is also described. The types of specimens described and the methods of externally loading and corrosion testing the specimens have been found to be reliable for stress corrosion evaluation of most aluminum alloys, and have shown promise for ferrous and nickel alloys. Author

N67-24651# Marine Engineering Lab., Annapolis, Md.
SURVEY OF PRESENT INFORMATION ON ELASTOHYDRODYNAMIC LUBRICATION OF GEARING
L. G. Schneider Feb. 1967 70 p refs
(MEL-369/66; AD-646896) CFSTI: HC $3.00/MF $0.65

The report is a survey of numerous published theoretical and experimental investigations in elastohydrodynamic lubrication with the intent of establishing their applicability to design and to lubrication investigations related to future high performance Navy gearing. While great progress in understanding the parameters of importance in elastohydrodynamic lubrication has been made, workable solutions for use in normal design are available only for limited conditions which are realized in rolling contact when little or no sliding occurs. In gearing, this condition exists only at the pitch point so that theoretical prediction of oil-film thickness becomes increasingly overly optimistic as tooth contact distance from the pitch line (and thus sliding velocity) increases. Author (TAB)

N67-24663# Southwest Research Inst., San Antonio, Tex.
FUNDAMENTAL INVESTIGATION OF LIQUID-METAL LUBRICATED JOURNAL BEARINGS Topical Report No. 2
R. A. Burton and Y. Hsu 12 Jan. 1967 88 p
(Contract AT(11-1)-1228)
(SWRI-1228P8-32) CFSTI: HC $3.00/MF $0.65

By reference to new experimental data and by numerical calculations which exploit and extend the applicability of one of the more promising techniques, the behavior of crossed Couette and pressure flows can be predicted with good accuracy. Experimental results showed large pressure changes near discontinuities in the bearing surfaces such as found in stepped pads and in spiral-groove bearings. Generalizing the pressure rise data for the entry region of pads, this effect as a boundary condition in computations of the performance of tilted pads was discussed. In view of the foregoing critical discussions, it seems that the calculated performance is realistic. The fact that pad-tipping is predicted by these calculations, under some circumstances, should serve as a warning to designers. The negative pressure observed in stepped pads and spiral-groove configurations indicates conditions under which films would be expected to cavitate. Since this may also lead to malfunction of the bearing or seal, such observations are expected to lead, ultimately, to statements of design limitations. They also serve to provide explanations of previously observed film-breakup in such configurations as the screw-thread seal, a topic which has been the subject of considerable speculation and mystery. Author (NSA)

N67-24882# Naval Research Lab., Washington, D. C.
ARPA COUPLING PROGRAM ON CORROSION Quarterly Report
E. P. Dahlberg, ed. Dec. 1966 11 p
(Contracts Nonr-610(09); Nonr-760(31); N00014-66-C0365; ARPA Orders 878; RR-007-08-44-5512)
(NRL-MR-1739; QR-1; AD-645859) CFSTI: HC $3.00/MF $0.65

A progress report of the research investigation being carried out on the problem of stress-corrosion cracking of high strength materials is presented. Work concerning physical metallurgy, surface chemistry, fracture mechanics, and characterization tests and translation related to stress-corrosion cracking is described. The materials being studied include high strength steels, titanium alloys, and aluminum alloys. Author (TAB)

N67-25182# Naval Air Engineering Center, Philadelphia, Pa. Aeronautical Materials Lab.
EVALUATION OF MIL-P-23377 AND MIL-P-0023377 AMENDMENT 2 EPOXY PRIMERS ON 7075 ALUMINUM CONTAINING CADMIUM PLATED HIGH STRENGTH STEEL FASTENERS
J. Ohr and A. I. Falkowitz 13 Dec. 1966 21 p refs
(NAEC-AML-2530; AD-648180) CFSTI: HC $3.00/MF $0.65

A comparison is made of the corrosion protection of MIL-P-0023377, Amendment 2 and MIL-P-23377 epoxy primers, used on thick 7075 aluminum with cadmium plated high strength steel fasteners and topcoated with either MIL-C-22750 epoxy or MIL-L-81352 acrylic lacquer. Superiority of the former primer, as evidenced by greater protection around fasteners where paint had cracked, is attributed to higher leaching of chromate in both distilled and sea water. Preferential use of former is recommended. TAB

N67-25339# SKF Industries, Inc., King of Prussia, Pa. Research Lab.
ROLLING CONTACT FAILURE CONTROL THROUGH LUBRICATION Special Research Report
T. E. Tallian 19 Sep. 1966 118 p refs
(Contracts Nonr-4433(00); Nonr-4895(00); NOw-61-0716-c; NOw-64-0428-c; NOw-65-0182-f; et al)
(AL66Q028; AD-641189) CFSTI: HC $3.00/MF $0.65

The paper is subdivided into the following sections: (1) Description of typical rolling contact failure modes, (2) Review of parameters influential in causing contact failure, (3) Observations on rolling contacts which relate failure mechanism to engineering parameters of the contact, and specifically to lubrication. TAB

N67-25356# Oak Ridge National Lab., Tenn.
MATERIALS COMPATIBILITY
J. H. De Van *In its* Metals and Ceramics Div. Oct. 1966 p 81–84 refs (See N67-25341 13-22)

Corrosion in the Nb–O–K system at 1000 and 1250°C is controlled by solid-state diffusion of O_2 from the NbO. The driving force seems to be the tendency to form mixed metal oxides, in agreement with previous results at lower temperatures. At 815°C Nb–1% Zr specimens containing an oxygen-to-Zr atom ratio less than 2 took up oxygen, while specimens with a ratio greater than 2 lost oxygen. Thus the direction of oxygen movement appears to depend on whether the atom ratio of oxygen is less than or greater than that corresponding to ZrO_2. A unique fast-neutron activation analysis facility suitable for handling highly active alkali metals without protective capsulation was designed and is under construction. A molecular distillation rig is being developed which is capable of refining alkali metals to higher purity than has been possible with other methods. Author (NSA)

N67-25377# Oak Ridge National Lab., Tenn.
SNAP–8 AND SNAP–50 CORROSION STUDIES
A. P. Litman and A. Taboada *In its* Metals and Ceramics Div. Oct. 1966 p 245 refs (See N67-25341 13-22)

Corrosion support programs for the SNAP–8 and SNAP–50 reactor systems were continued. Studies on the former were completed, and a summary report was issued. The most pronounced performance-deteriorating corrosion phenomenon found was C migration from the Croloy 9M to the other structural materials in the system (chromized Hastelloy N, types 347 and 316 stainless steel, and Hastelloy C) in contact with the eutectic NaK. The bimetallic heat-rejection loop, made from type 316 stainless steel and Nb–1% Zr alloy, studied in support of SNAP–50, completed its scheduled 6000-hr operation with eutectic NaK, was dismantled, and is being examined. Removable and permanent specimens of both structural metals located in the heated section showed very small or no weight change. Author (NSA)

N67-25390# Rocky Flats Div., Dow Chemical Co., Golden, Colo.
ABSTRACT OF BEARING DEVELOPMENTS AND DATA ON SPINDLES
H. S. Green and A. E. Rains 4 Nov. 1966 30 p refs Presented at the 7th Intern. Machine Tool Des. and Res. Conf., Birmingham, England, 12–16 Sep. 1966
(Contract AT(29-1)-1106)
(RFP-734) CFSTI: HC $3.00/MF $0.65

The history of the development of bearings and spindles since the early 19th century, and causes of bearing failures are discussed. Comparisons are given of the different types of bearings which can be used to complement the spindle and classification terminology and ratings are explained and illustrated. Information is also presented on contemporary measurement definitions and bearing nomenclature; gaging practices associated with bearings; and typical high-accuracy bearing specifications. NSA

N67-25911# Japan Atomic Energy Research Inst., Tokyo.
CORROSION OF ZIRCALOY-2 AND 4 IN HIGH TEMPERATURE AND HIGH PRESSURE BOILING WATER AND STEAM
Sueo Nomura and Noboru Ito Aug. 1966 11 p refs In JAPANESE; ENGLISH summary
(JAERI-1116) CFSTI: HC $3.00/MF $0.65

Two kinds of Zircaloy-2 and one kind of Zircaloy-4 were corroded in 280°C boiling water and 400°C steam at pressure 64 kg/cm^2 G. Remarkable corrosion was observed where a stringer was located, and the corrosion was larger in the flowing condition of water or steam than in the stagnant. Further, it was increased with increasing oxygen content of the water or steam. By the weight gain-time curves for the three kinds of specimens, it was indicated that the difference in weight gain was caused by the difference in the reaction rate constants of the different specimens, although the time dependency of weight gain was constant. The difference in the reaction rate constant was considered as due to the morphological difference of the corroded specimen surfaces, by the impedance measurement and optical- and electron-microscopic observation of the surface oxide films of the specimens. Author (NSA)

N67-26039 Metaalinstituut TNO, Delft (Netherlands).
QUALITY CONTROL AND SUGGESTED METHODS FOR PROTECTION OF ANODIZED ALUMINUM DRIVE SHAFTS OF HELICOPTERS [EEN KWALITEITSONDERZOEK VAN DE BESCHERMING VAN GEANODISEERDO ALUMINUM AANDRIJFASSEN VAN HELICOPTERS]
M. J. Reidt 31 Jan. 1967 10 p refs In DUTCH
(M67-116; TDCK-47506) CFSTI: HC $3.00

Anodized aluminum tail rotor drive shafts were examined for effectiveness of corrosion protection. An accelerated salt spray test method was used. Thickness, porosity, and homogeneity of the coatings were measured. Structure of the aluminum and density of the coatings were microscopically determined. Attention was paid to the possibility of intercrystalline corrosion. A quatitative spectrographic analysis was made of the most important elements and impurities in the aluminum. A method for improving the corrosion resistance through application of a ± 15-μ lacquer coating is suggested. Transl. by K.W.

N67-26040*# Verfinstituut TNO, Delft (Netherlands).
COMPARISON OF SEVERAL METHODS FOR TREATING STEEL PRIOR TO PAINTING [VERGELIJKEND ONDERZOEK VAN EEN AANTAL VOORBEHANDELINGEN VAN STAAL, DAT WORDT GESCHILDERD]
19 Jan. 1967 27 p refs In DUTCH
(V-67-21; TDCK-47320) CFSTI: HC $3.00/MF $0.65

Twenty-one combinations of cleaning methods and primer paint systems were tested and evaluated for application on cold-rolled steel sheets. The mechanical evaluation consisted of adhesion,

scrape, pressure, and impact tests. Corrosion tests were conducted to determine resistance to salt spray, aerosol exposure, condensation, and water immersion. Three primer paint systems based on phtalate, styrene alkyd, and cellulose derivative/alkyd were used. All results are shown in tables. Transl. by K.W.

N67-26161* Northrop Corp., Hawthorne, Calif. Norair Div.
DEVELOPMENT OF AN ACCELERATED STRESS CORROSION TEST FOR FERROUS AND NICKEL ALLOYS Annual Summary Report, 17 Mar. 1966–17 Jan. 1967
A. H. Freedman Feb. 1967 64 p refs
(Contract NAS8-20333)
(NASA-CR-83970; NOR-67-12) CFSTI: HC $3.00 CSCL 11F

An accelerated laboratory test was developed for evaluating stress corrosion susceptibility of ferrous and nickel alloys in a seacoast environment. Materials investigated included H-11, 4340, 18Ni Maraging steel, 410 SS, 17-4PH, AM355, 304 SS, and Inconel 718. The test was based upon the use of single-edge-notched and fatigue-cracked specimens tension-loaded under plane strain in a 20-percent NaCl corrodent at room temperature. A nominal specimen thickness of 1/4 inch was adequate for determining threshold stress intensities and stress intensity ratios for stress corrosion under plane strain in all program materials except 17-4PH (H-1150), 304 SS, and Inconel 718. The accelerated test required a maximum test time of 1000 hours. Test times were one to three orders of magnitude shorter than test times required for similar specimens in a seacoast environment. The accelerated test time was produced by the aggressive corrodent, the presence of a crack, and plane strain loading conditions. Fractographic analyses showed that specimens tested by the accelerated test exhibited stress corrosion fracture modes similar to those observed in specimens tested in a seacoast environment. Author

N67-26543*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BEARING TORQUE AND FATIGUE LIFE STUDIES WITH SEVERAL LUBRICANTS FOR USE IN THE RANGE 500°F TO 700°F
Richard J. Parker, Eric N. Bamberger (GE, Cincinnati, Ohio), and Erwin V. Zaretsky Washington, NASA, May 1967 22 p refs
(NASA-TN-D-3948) CFSTI: HC $3.00/MF $0.65 CSCL 13I

Bearing torque decreased with increasing outer-race temperature up to 700°F for all seven lubricants. Increasing torque was observed with increased lubricant viscosity. Of four lubricants tested between 700° and 900°F outer-race temperature and lubricant-mist temperatures of 450° to 620°F, only the synthetic paraffinic oil with the antiwear additive showed no abrupt torque increase as the outer-race temperature was increased. Furthermore, increasing the lubricant-mist temperature had no effect on bearing torque. These results indicated that the lubricant mist had little cooling effect on the bearing. Apparent elastohydrodynamic lubrication, based on running track appearance, was indicated with all seven lubricants to outer-race temperatures of 700°F when sufficient lubricant flow was maintained. Fatigue tests were conducted at 600°F with a synthetic paraffinic oil plus an antiwear additive, a polyphenyl ether with an oxidation inhibitor, and a fluorocarbon with no additives. The synthetic paraffinic oil exhibited 10-percent fatigue lives 2 and 3 times greater than the lives obtained with the fluorocarbon and the polyphenyl ether lubricants, respectively. Author

N67-26638*# General Electric Co., Cincinnati, Ohio.
ADVANCED REFRACTORY ALLOY CORROSION LOOP PROGRAM Quarterly Progress Report, Period Ending 15 Jan. 1967
R. W. Harrison, ed. 28 Jan. 1967 56 p
(Contract NAS3-6474)
(NASA-CR-72230; QPR-7) CFSTI: HC $3.00/MF $0.65 CSCL 11F

The T-111 alloy tubing was received and quality assurance inspection is in progress. Most of the T-111 alloy materials were released for the manufacture of critical components; the remaining necessary materials are being inspected. Fabrication and installation of the lithium still into the purification system was completed and outgassing is in progress. Fabrication of many of the loop components is in progress. Author

N67-26780# Titanium Metals Corp. of America, New York.
METASTABLE BETA SHEET ALLOY Ti–8Mo–8V–2Fe–3Al, PART I Final Technical Report
Donald B. Hunter Oct. 1966 101 p
(Contract DA-30-069-ORD-3743)
(WAL-TR-405/2-14, Pt. 1; AD-648244) CFSTI: HC $3.00/MF $0.65

A 500-lb. ingot of metastable beta alloy Ti-8Mo-8V-2Fe-3Al was melted and mill processed to plate and sheet for evaluation. No processing problems were encountered. Plate samples were evaluated in 2 in and 1/2 in sections; room temp. and 600F smooth and notched tensile properties and K sub ic values were obtained. Samples taken from both sections of plate, when solution treated and aged for 16 hrs. at 900F, had room temp. yield strengths of 190-200Kpsi; K sub ic values were 45-48Kpsi-square root of (in). Sheets of 0.040 and 0.060 in gage were evaluated by determining 50 and 100% recrystallization parameters, using mill annealed sheet and hot rolled sheet given 25 and 50% cold reduction. Aging response of these materials was then determined at 800-1200F and tensile properties evaluated after selected treatments. From this, 8 conditions of heat treatment were selected for further evaluation by sub-zero and 600F smooth and notched tensile, bend, notched fatigue and K sub ic tests, measurement of creep stability; stress corrosion resistance and oxidation characteristics; and study of welding behavior. Ti-8Mo-8V-2Fe-3Al possessed good notch tensile strength over the range of -65 to 600F; the notched fatigue limit, with a notch configuration of Kt = 3.5, was 30-35Kpsi, and the plane strain crack propagation resistance was 45-60Kpsi-square root of (in). Creep curves were obtained, employing loads of 90% of the yield strength at 600F, for exposure times of 500 hrs. Author (TAB)

N67-27281*# General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.
MATERIALS FOR POTASSIUM LUBRICATED JOURNAL BEARINGS Quarterly Progress Report, 22 Apr.–22 Jul. 1966
R. G. Frank, ed. 22 Jul. 1966 135 p refs
(Contract NAS3-2534)
(NASA-CR-72239; QPR-13) CFSTI: HC $3.00/MF $0.65 CSCL 11F

Friction and wear tests on candidate bearing material combinations are reported. Materials involved in the testing program were Mo–TZM alloy vs Carboloy 907, Carboloy 907 itself, Grade 7178 vs Mo–TZM alloy, and Mo–TZM alloy vs TiC+10%Nb. Tests were conducted at Rt, 400°, 800°, and 1200°F at pressures of 10^{-9} torr, and speeds of 800 SFM. Other friction and wear tests with these materials were successfully completed in liquid potassium at 400° and 800°F at speeds of 1,000 SFM. Chemical analyses of the potassium sampled before and after the tests were conducted indicated an oxygen content of less than 10 ppm. Results of compression tests of 13 candidate bearing materials are also reported. L.S.

N67-27319*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
IMPORTANCE IN LUBRICATION OF VARIOUS INTERFACE TYPES FORMED DURING VACUUM DEPOSITION OF THIN METALLIC FILMS
T. Spalvins and D. H. Buckley Washington, NASA, 1967 18 p refs Presented at the 10th Vacuum Metal. Conf., New York, 13–15 Jun. 1967
(NASA-TM-X-52305) CFSTI: HC $3.00/MF $0.65 CSCL 13H

Various vacuum deposition methods are used to deposit soft, thin metal gold films on metal surfaces for lubrication purposes. When a metal film is deposited on a surface, the adhesion characteristics of the deposited metal film to the substrate depend on the type and structure of the interfacial region. This interfacial region is directly related to the solid solubility and alloying concepts. The type or nature of the interface directly influences the endurance and strength properties of a lubricating film. Three vacuum deposition methods were used here: (1) vapor deposition, (2) sputtering, and (3) ion plating. The characteristics of the film and interface were examined in friction experiments in ultra high vacuum. The coefficient of friction was used to determine the strength and durability of the deposited film. Depending on the vacuum deposition method and the selection of film and substrate material, five types of interfaces can be distinguished. The diffusion and high energy embedded interfaces are desirable because a graded, layer-like interface is formed. Author

N67-27430*# Kaiser Aluminum and Chemical Corp., Spokane, Wash. Dept. of Metallurgical Research.
DEVELOPMENT OF A RAPID STRESS CORROSION TEST FOR ALUMINUM ALLOYS Annual Report, 1 Mar. 1966–1 Mar. 1967
N. J. Helfrich 15 Mar. 1967 64 p
(Contract NAS8-20285)
(NASA-CR-84441) CFSTI: HC $3.00/MF $0.65 CSCL 11F

Various media were investigated for use in accelerated stress corrosion tests of aluminum alloys. In general, aqueous solutions of NaCl–K_2 Cr_2 O_7 were very effective in causing rapid short-transverse failures in the absence of excessive general surface corrosion. However, the stress corrosion performance of any one alloy and temper was dependent upon the solution pH and temperature. Neutral salt-(di)chromate solutions promoted rapid stress corrosion failures in susceptible tempers of 2024 and 2219. Neutral salt-(di)chromate solutions are relatively innocuous towards unstressed aluminum alloys. As such, they would be preferred to the more corrosive 3.5% NaCl solution employed in alternate immersion tests. Consideration has been given to modification of the neutral salt-(di)chromate solution with additions of strong oxidizing agents and use of buffered sodium chloride solutions in accelerated stress corrosion tests. Author

N67-27469# Naval Air Engineering Center, Philadelphia, Pa. Aeronautical Materials Lab.
THE CORROSION PROTECTION OF ANTIMONY OXIDE PRIMERS OVER AIRCRAFT METALS
Jack Ohr 9 Dec. 1966 4 p
(NAEC-AML-2532; AD-648228) CFSTI: HC $3.00/MF $0.65

Past and recent work covering antimony oxide primers was restudied, and from this, conclusions were drawn as to their practical merits in the corrosion prevention of modern military aircraft. TAB

N67-27506*# Douglas Aircraft Co., Inc., Newport Beach, Calif. Astropower Lab.
STRESS CORROSION CRACKING OF TITANIUM ALLOYS AT AMBIENT TEMPERATURE IN AQUEOUS SOLUTIONS Progress Report, Jun.–Aug. 1966
C. B. Gilpin Oct. 1966 26 p refs
(Contract NAS7-488)
(NASA-CR-84472; SM-49105-Q1) CFSTI: HC $3.00/MF $0.65 CSCL 11F

During this period a literature survey was made on subjects related to this problem area. The approach to experimental studies has been discussed. Preliminary electrochemical evaluations were conducted. Potentiostat curves for Ti–5Al–2.5Sn and Ti–6Al–4V in 3% NaCl, pH 6.5, were determined. Oxygenation was observed to shift the cathodic polarization curves in an electropositive direction, but did not greatly affect the anodic curves. Stress of 80% of the yield strength did not greatly affect the cathodic polarization but did reduce the anodic passivation for both alloys. Author

N67-27509*# Boeing Co., Seattle, Wash. Launch Systems Branch.
METALLURGICAL ANALYSIS OF FILTER HOUSING ASSEMBLY 60B83104-1, SERIAL NUMBER 69 FAILURE
C. B. Schwartz 12 Sep. 1966 20 p refs
(Contract NAS8-5608)
(NASA-CR-84475; T5-6539-80) CFSTI: HC $3.00/MF $0.65 CSCL 13I

Filter Housing Assembly, 60B83104-1, Serial 69 was discovered leaking from a defect in the side of the housing. The housing is 7075-T6 aluminum alloy. Examination of the fracture pattern and material microstructure led to the conclusion that failure was by stress corrosion cracking. Future failures of the part by stress corrosion cracking can be avoided by heat treating the housing to a T73 temper. Author

N67-27519*# Boeing Co., Seattle, Wash. Launch Systems Branch.
THRUST RING SPLICE ANGLE INVESTIGATION
R. R. Sands 9 Dec. 1966 11 p
(Contract NAS8-5608)
(NASA-CR-84479) CFSTI: $3.00 CSCL 13H

The failed thrust ring splice angle (60B18616-1) discovered during the post test shake down inspection of the S–IC "D" vehicle, was analyzed. Standard metallurgical testing and electron fractography revealed that the crack inception was on the faying side of the angle and was due to stress corrosion. Author

N67-28006*# Boeing Scientific Research Labs., Seattle, Wash. Solid State Physics Lab.
STRESS CORROSION CRACKING OF TITANIUM ALLOYS HEAT TREATMENT EFFECTS, SCC VELOCITY IN VARIOUS SOLVENTS AND ELECTROCHEMICAL KINETICS WITH Ti:8-1-1 ALLOY Quarterly Progress Report, 1 Oct.–31 Dec. 1966
T. R. Beck Dec. 1966 48 p ref
(Contract NAS7-489)
(NASA-CR-84653; QPR-2) CFSTI: HC $3.00/MF $0.65 CSCL 11F

Stress corrosion cracking of titanium:8%Al–1%Mo–1%V alloy was studied. Pre-cracked specimens were introduced to the studies resulting in lower failure loads and providing a wider range of stress for study. Heat treatment effects and various solvent environments were investigated. Electrochemical kinetic measurements were made to obtain more quantitative numbers for the parameters used in the electrochemical models describing velocity control. One of the interesting findings is that SCC of Ti:8-1-1 occurred in pure water and methanol, but could be suppressed by addition of small amounts of nitrate or sulfate—on the order of 10–100 ppm. The Ti:8-1-1 was also susceptible to SCC in chlorinated solvents such as carbon tetrachloride, methylene chloride and trichlorethylene. Heat treatment has a very marked effect on fracture load and crack velocity. Evidence from the kinetic studies indicates that the hydride mechanism does not play a role in SCC of Ti:8-1-1 under the conditions used. Author

N67-28040 Royal Aircraft Establishment, Farnborough (England).
A REVIEW OF CURRENT INFORMATION ON Ti–8Al–1Mo–1V ALLOY SHEET
A. R. G. Brown Sep. 1964 29 p refs
(RAE-TR-64003)

A review of published data on the Ti–8Al–1Mo–1V alloy is given; data are quoted for tensile strengths, compressive strengths, tensile and compressive moduli, fatigue strength, stability under load, weldability, static residual strength and susceptibility to hot salt stress corrosion. Author

N67-28242# Rock Island Arsenal Lab., Ill. Research and Engineering Div.
LUBRICITY CHARACTERISTICS OF CORROSION PREVENTIVE OILS
Charles J. Quilty Dec. 1966 26 p refs
(RIA-66-3514; AD-649098) CFSTI: HC $3.00/MF $0.65

In the study, seventeen qualified preservative oils were investigated to establish their lubricity properties. The oils were tested in a Shell Four-Ball Wear Tester at selected loads and the wear scars measured. The viscosity and acidity of each oil were determined before and after wear test. Adhesive wear particles formed during wear tests were examined microscopically and their size shown to be an indication of the lubricating ability of the oil. Results indicate that these oils leave considerable room for improvement in their lubricating ability. A new method, using thermometric titrimetry, was developed for determining acidity in new and used corrosion preventive and lubricating oils. The total acid numbers obtained by colorimetric, potentiometric, and thermometric methods were compared. Author (TAB)

N67-28245# Naval Research Lab., Washington, D. C.
ANALYSIS OF STRESS-CORROSION CRACKING OF Ti-6Al-4V FUEL TANK MATERIAL IN METHYL ALCOHOL
D. A. Meyn, E. P. Dahlberg, and C. D. Beachem Jan. 1967 24 p refs
(NRL-MR-1744; AD-649187) CFSTI: HC $3.00/MF $0.65

Material from a high yield strength 6Al-4V titanium alloy space vehicle fuel tank was found to be susceptible to stress-corrosion cracking in methyl alcohol by an unidentified cleavage mechanism. Cracks propagated in contact with methanol at plane strain stress intensities as low as 15 ksi in. The same material was found to be somewhat susceptible to cracking in distilled water, by the same mechanism, with a crack propagating at a plane strain stress intensity of about 30 ksi in. Author (TAB)

N67-28270# Army Weapons Command, Rock Island, Ill. Research and Engineering Div.
THE ROLE OF ACIDITY AND BASICITY OF A GREASE IN RELATION TO ITS EFFECTIVENESS AS A LUBRICANT AND CORROSION INHIBITOR
Joseph M. Bish Feb. 1967 27 p refs
(RIA-TR-67-342; AD-649103) CFSTI: HC $3.00/MF $0.65

A series of twenty four greases were selected for this work. Eight of the greases were commercial greases selected from a variety in use today. Eight other greases were made up from an uninhibited calcium hydroxy stearate grease with various combinations of extreme pressure agents, anti-oxidants and rust inhibitors as additives. Eight greases were also prepared from uninhibited MIL-G-10924B grease and the same combination of additives used in the preparation of the calcium hydroxy stearate greases. Acid numbers were determined by the Rock Island Arsenal Method, Fed. Std. 791a-5105.3, ASTM D-974, ASTM D-974 modified, and ASTM D-664. There was a wide variation in the acid and base number obtained by these methods, indicating that each method measures a different property of the grease. Wear and oxidation tests made on the greases were the Shell Four Ball Wear, Falex Rate Wear, Copper Corrosion, Oxidation Stability, and Rust Preventive Properties of Lubricating Greases. It was found that a high acid number does not always indicate poor wear or poor oxidation stability. Both molybdenum dibutyldithiocarbamate and the additive containing molybdenum, sulfur, and phosphorus, when added to the two uninhibited greases gave an increase in acid number and a decrease in wear scar. Author (TAB)

N67-28271# Army Weapons Command, Rock Island, Ill. Research and Engineering Div.
LOAD AND TEMPERATURE AS RELATED TO SOLID FILM LUBRICANT WEAR LIFE
George Murphy, Jr. Jan. 1967 30 p refs
(RIA-TR-67-214; AD-649102) CFSTI: HC $3.00/MF $0.65

A representative solid film lubricant for each specification, MIL-L-8937(ASG), MIL-L-46009(MR) and MIL-L-46010(MR), was evaluated on the Falex Wear Tester under various combinations of test load and temperature. Based on a statistical analysis of the data the following conclusions can be made (1) The effect of temperature on wear life depends on both solid film lubricant type and test load. (2) The wear life of heat cured solid film lubricants is decreased by increased temperature at the lower test loads. The wear life of air cured solid film lubricants is affected very little by temperature. (3) The effect of load on wear life is dependent on lubricant type but not on temperature. (4) For heat cured solid film lubricants a constant short wear life under high loads occurs followed by a rapid increase in wear life with decreasing load and finally a leveling off of wear life with further decreasing of the load. (5) For the air cured solid film lubricant there is a constant short wear life over an extended load range followed by a rapid increase in wear life with a further decrease in load. Over the load range used there is no apparent leveling off of wear life under the low load condition. Author (TAB)

N67-28384# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
EFFECT OF RADIAL CLEARANCE ON JOURNAL STABILITY IN GAS-LUBRICATED BEARINGS
G. A. Pospelov 20 Dec. 1966 15 p refs Transl. into ENGLISH from Tr. Aviats. Inst. Kazan (USSR), no. 81, 69–80
(FTD-TT-65-1404; TT-67-61332; AD-649033) CFSTI: HC $3.00/MF $0.65

In investigations of stability, the assumption that the reaction of the oil film is independent of the speed of the center of the journal is frequently employed. The author solved the problem of determining the forces in a gas film, which arise in the case of disturbed journal movement. The circumferential components of these forces are determined on the basis of the expression for the determining factor of the gas lubricant. The radial components are computed by an approximate solution of the differential equation describing the forward motion of the journal. The Trefts method is used in the solution. After substitution of the forces in the motion equation, a characteristic equation is written, which is studied for stability by the Raus-Gurvits method. An instability zone boundary diagram is presented in 'dimensionless eccentricity load angle' coordinated. TAB

N67-28508# Battelle Inst., Frankfurt am Main (West Germany).
BASIC RESEARCH INTO THE FRICTION BETWEEN NON-LUBRICATED SOLID BODIES INCLUDING ELEVATED TEMPERATURES Final Report, Jan.–Dec. 1964
G. Bohme, G. Sperling, and H. Krupp Wright-Patterson AFB, Ohio, AF Mater. Lab., Jan. 1967 108 p refs
(Contract AF 61(052)-745)
(AFML-TR-64-418; AD-649550) CFSTI: HC $3.00/MF $0.65

A review is given of the design and construction of a mechanically driven ultracentrifuge and of the measurements performed with this device. The reasons for discontinuing the work with this centrifuge are discussed. A newly built ultracentrifuge with transistorized drive is described; several systems for heating the rotor are shown. First measurements with this centrifuge and measuring results are described. The theoretical investigations of the separation of small particles from a solid body are based on the known laws for sinter and creep processes at elevated temperatures; they lead to an expression for the dependence of the creep rupture time on the experimental variables. The elasticity calculations furnished rigorous solutions for the vertical and tangential displacement of an elastic semi-infinite body under the action of an external pointshaped center of attraction. For the deformation of the elastic semi-infinite body by the action of an external

spherical center of force with attractive and repulsive forces approximate solutions can be proposed. The appendix deals with the solution of boundary value problems of elastostatics in general and for the specific case of the elastic sphere and the elastic semi-infinite body by methods of the potential theory. Author (TAB)

N67-28600# Virginia Polytechnic Inst., Blacksburg. Dept. of Metals and Ceramic Engineering.
THE RELATIONSHIP OF NITROGEN CONTENT OF AUSTENITIC STAINLESS STEELS TO STRESS CORROSION Quarterly Report, 1 Oct.–31 Dec. 1966
Thomas B. Cox and John F. Eckel 31 Dec. 1966 24 p refs
(Contract AT(40-1)-3208)
(EURAEC-1806; QR-10; Rept.-438-10) CFSTI: HC $3.00/MF $0.65

Developments are reported for: production of thin foils of Type-304 stainless steel; etching procedure for Type-304 stainless steel; N_2 solubility in AISI Type-304 at 871 and 927°C; and thermodynamic properties of the solution process for N_2 in stainless steel. NSA

N67-28602# Naval Air Engineering Center, Philadelphia, Pa. Aeronautical Materials Lab.
CORROSION RESISTANCE AND DURABILITY OF FASTENERS IN AIRCRAFT STRUCTURES Progress Report, Jul. 1965–Feb. 1967
Joseph Viglione 26 Jan. 1967 44 p refs
(NAEC-AML-2529; AD-651189) CFSTI: HC $3.00/MF $0.65

A corrosion and fatigue evaluation was made to determine whether the rounding of countersunk holes and/or fastener heads would improve the corrosion behavior at the fastener locations or affect the fatigue strength of 7075-T6 aluminum alloy joints assembled with cadmium plated steel countersunk head screws. Test assemblies were prepared with and without corrosion barrier materials, including a MIL-S-8802 polysulfide sealant, in the finishing system. Rounded configurations did not significantly improve corrosion behavior but did improve the fatigue strength of the specimens. The greatest improvement in fatigue properties occurred with a combination of rounded fastener heads and rounded countersunk holes. Of the various corrosion barrier materials tested, only the polysulfide sealant afforded good corrosion protection when used with a paint system overcoat. However, the use of the sealant more than negated the beneficial effect of the rounded configurations on fatigue strength. The use of the sealant lowered the fatigue strength of the control specimens with standard fastener heads and standard countersunk holes by approximately 6%. This loss is counterbalanced by the improvement in corrosion behavior afforded by the sealant to fastener areas. Author (TAB)

N67-28629# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
NEWS IN MACHINE LUBRICANTS, CHAPTER IV AND V
M. V. Korovchinskiy 16 Feb. 1967 141 p refs Transl. into ENGLISH from the book "Novoye O Smazke v Mashinakh" Moscow, Izd. Nauk, 1964 p 68–176
(FTD-MT-65-401; TT-67-61601; AD-650806) CFSTI: HC $3.00/MF $0.65

Limiting cases of a two-dimensional elasto-hydrodynamic problem for two cylinders with parallel generatrices are analyzed. The values are found for finite extension of a lubricating layer at which the oil flow deviates scarcely from a plane and the influence of compressibility of the lubricant and heat emission in the lubricating layer on its supporting power and pressure distribution in it is analyzed. The effect of a change is viscosity with the change in temperature on an adiabatic flow of an incompressible lubricant is examined. Experiments with small loads on cylinders are described. The above-mentioned problem is also analyzed for the case of local contact between generatrices and a method is given to solve a problem concerned with isothermal flow of a lubricant and relative slip of an elastic cylinder for small values of rigidity numbers. An extensive bibliography is included of the 1961 literature on theory and calculations of thrust bearings, and on lubricants. TAB

N67-28636# Naval Air Engineering Center, Philadelphia, Pa. Materials Application and Engineering Div.
DEVELOPMENT OF DESIGN FACTORS FOR AN OIL FREE LUBRICATED INTERNAL COMBUSTION GASOLINE ENGINE
J. P. Cerini 28 Sep. 1966 14 p refs
(NAEC-AML-2460; AD-650098) CFSTI: HC $3.00/MF $0.65

Test results of an oil free, solid film lubricated internal combustion gasoline engine employing molybdenum metal and reservoirs for lubricant in selected wear zones show a performance life of 6 hours at speeds of 2500 - 3000 rpm. A similar test engine run at low temperatures shows a rapid starting capability at -65F. Author (TAB)

N67-28638# Naval Air Engineering Center, Philadelphia, Pa. Materials Application and Engineering Div.
LUBRICATION EFFECTS OF CHEMICAL COMPOUNDS CONTAINED IN SEA WATER
Neal D. Rebuck 21 Dec. 1966 8 p
(NAEC-AML-2555; AD-650094) CFSTI: HC $3.00/MF $0.65

The report covers laboratory research on the use of sea water as a possible lubricant for bearing components of ocean vehicles and equipment. Focus is on the improved lubricating effect generated by sulfur compounds in contact with molybdenum surfaces. Results show sea water to exhibit the properties of a lubricating fluid for steel vs. molybdenum and bronze vs. molybdenum bearing combinations. Author (TAB)

N67-28748*# General Electric Co., Cincinnati, Ohio. Missile and Space Div.
COMPATIBILITY OF BIAXIALLY STRESSED D-43 ALLOY WITH REFLUXING POTASSIUM
R. W. Harrison Washington, NASA, Jun. 1967 45 p refs
(Contract NAS3-6012)
(NASA-CR-807) CFSTI: HC $3.00/MF $0.65 CSCL 11F

The purpose of the tests was to determine the effects of stress on corrosion of an advanced refractory alloy when the stress is sufficiently large to produce substantial creep. D-43 columbium-base alloy in the form of welded capsules was selected for the tests. The reflux capsules were tested under conditions which resulted in about 5% to 10% strain during a 500-hr to 2000-hr exposure period in the 2000° to 2200° F temperature range. The capsule wall was reduced in the potassium liquid region and in the vapor condensing region to provide gauge sections for measuring the extent of creep. This permitted moderate temperature adjustments during the initial phase of the testing to achieve the desired strain-time conditions. Post-test evaluation included metallographic examination of grain structure and micro-hardness; chemical analysis; and electron microprobe analyses of carbon, oxygen, nitrogen, tungsten, and zirconium content profiles. K.W.

N67-28796*# Melpar, Inc., Falls Church, Va. Materials Lab.
THE DEVELOPMENT OF DISPERSION-STRENGTHENED NICKEL-BASE CORROSION-RESISTANT ALLOYS
May 1967 16 p refs
(Contract NAS3-7271)
(NASA-CR-54580) CFSTI: HC $3.00/MF $0.65 CSCL 11F

The results of a program to produce a 70 nickel–20 chromium–10 molybdenum alloy by vapor plating in a fluidized bed of oxide particles are described. The nickel vapor was obtained by

thermally decomposing nickel carbonyl, $Ni(CO)_4$. The chromium vapor was obtained by decomposing dicumene chromium, $Cr(C_9H_{12})_2$, and the molybdenum vapor was obtained by reducing molybdenum pentachloride, $MoCl_5$. Single and multi-element alloys were made. Metallographic examination of single-element deposit agglomerates of chromium or nickel showed a uniform particle distribution. Production of the triple-element dispersion-strengthened alloys by vapor deposition in a fluidized bed proved unsuccessful. The triple alloys were characterized by unusually high carbon contents, owing chiefly to the apparent decomposition of the carbonyl radical and carbon monoxide carrier gas used in vapor plating the nickel. The triple-element matrix alloys were also characterized by the presence of agglomerated oxide particles. These studies indicate that it is possible to vapor plate submicron oxide particles with either nickel or chromium and to obtain uniform fine oxide dispersions. The results of adding the nickel by an alternative method are also discussed. Author

N67-28834*# Aluminum Co. of America, New Kensington, Pa. Physical Metallurgy Div.
STUDY OF CRACK INITIATION PHENOMENA ASSOCIATED WITH STRESS CORROSION OF ALUMINUM ALLOYS Quarterly Report, 26 Dec. 1966–25 Mar. 1967
M. S. Hunter 24 Apr. 1967 101 p refs
(Contract NAS8-20396)
(NASA-CR-84850; QR-3) CSCL 11F

X-ray diffraction analyses of phases present in contract materials were completed and electron microprobe analyses of the 7075 alloy were made. The microprobe revealed certain heterogeneities but no indication that these were related directly to stress corrosion behavior. The attack on prepolished surfaces and in cross sections was similar, penetration in depth being much slower than stress-corrosion cracking rates. Light microscopy of crack initiation in the special tuning-fork specimen of most materials stressed short transversely to 75% YS was completed. In 2219-T37, cracks started and grew primarily on boundaries oriented normal to the stress. Preliminary investigations of the effect of stress level indicated that cracks develop in the same manner with 75% YS and 90% YS stresses but that localized surface deformation is much greater at the higher level. Author

N67-28882# Institute of Modern Languages, Inc., Washington, D. C. Translation and Interpretation Div.
GLASS IMMUNE TO FUMES OF ALKALI METALS [STECLO USTOICHIVOYE K PARAM SHCHELOCHNYCH METALLOV]
L. F. Shumitskaya, M. L. Gd'dfarb, and V. K. Tuzova Mar. 1967 4 p Transl. into ENGLISH from Byul. Izobret. i Tovarnykh Znakov (Moscow), v. 22, no. 3, 1966
(Contract DA-44-009-AMC-1563(T))
(T-1896-67; TT-67-61266; AD-648405) CFSTI: HC $3.00/MF $0.65

The glass consists of the following percents by weight: SiO2 12 plus or minus 2, B2O3 32 plus or minus 2, Al2O3 32.5 plus or minus 2, CaO 20 plus or minus 1.5, SrO 3.5 plus or minus 1.5 and contain not more than 0.03% Fe2O3. The glass does not crystallize during founding and working, it can be worked out well in the flame of a torch, articles with a wall thickness of 0.2-0.4 mm can be made of it, and it can be vacuum soldered to Kovar and molybdenum. TAB

N67-28906# Mechanical Technology, Inc., Latham, N. Y.
EFFECTS OF VISCOELASTIC LUBRICANT ON SQUEEZE FILM LUBRICATION BETWEEN IMPINGING SPHERES
Van C. Mow 24 Apr. 1967 32 p refs
(Contract 100014-66-C0037)
(MTI-67TR22; AD-651155) CFSTI: HC $3.00/MF $0.65

An asymptotic solution is obtained for squeeze flow between impinging spheres. The lubricant is assumed to be a four constant, nonlinear, viscoelastic liquid. The pressure peak in the lubricant is very sensitive to the values of viscoelastic constants. The results agree qualitatively with those observed experimentally. Author (TAB)

N67-29057# Mechanical Technology, Inc., Latham, N. Y.
ELASTOHYDRODYNAMIC THEORY OF SPHERICAL BODIES IN NORMAL APPROACH MOTION
Helge Christensen 24 Apr. 1967 46 p refs
(Contract N00014-66-C-0037)
(MTI-67TR21; AD-651154) CFSTI: HC $3.00/MF $0.65

The elastohydrodynamic problem of normal approach of two spherical bodies is studied and the lubrication and elasticity equations governing this type of motion are established. Numerical solutions to the general case accounting for elastic deformation of the bodies and pressure dependent viscosity are presented. Author (TAB)

N67-29070# ARO, Inc., Arnold Air Force Station, Tenn.
NITROGEN TETROXIDE–STAINLESS STEEL CRYOPANEL CORROSION AND COATING DEGRADATION IN SPACE CHAMBER PROPULSION TESTING Technical Report, Oct. 1965–30 Jun. 1966
P. G. Waldrep Arnold Eng. Devel. Center, Apr. 1967 34 p refs
(Contract AF 40(600)-1200)
(AEDC-TR-66-226; AD-650690) CFSTI: HC $3.00/MF $0.65

Corrosion of cryopanel metals in space simulation chambers caused by contamination by fuels, oxidizers, or exhaust gases arising from propulsion systems testing may be a serious problem. Since data taken under operational conditions is needed, a preliminary study using nitrogen tetroxide and 300-series stainless steel was initiated. The temperature was cycled between ambient conditions and 77K, and the pressure between 4 and 0.00001 torr of oxidizer. A black epoxy film covered some of the samples. Welded stainless steel 304 sustained general corrosion with some pitting, and intergranular corrosion was detected in heat-sensitized weld areas. Epoxy coated stainless steel 304 samples demonstrated no apparent damage in one series of short tests, but pit formation in the coating, pitting beneath the coating, and intergranular corrosion in weld areas was detected in a longer test. Heat-treated and polished stainless steel 304-L pitted to an indeterminate depth. An epoxy coated sample of similar material suffered microscopic cracking and blistering of the coating and surface pitting beneath. Author (TAB)

N67-29174*# Aerojet-General Corp., Sacramento, Calif. Research and Technology Operation.
INVESTIGATION OF N_2O_4 ENVIRONMENTAL EFFECTS ON SPECIALLY HEAT-TREATED Ti–6Al–4V ALLOY Final Report
[1966] 25 p ref
(Contract NAS9-6015)
(NASA-CR-65635) CFSTI: HC $3.00/MF $0.65 CSCL 11F

The mechanical properties and N_2O_4 stress corrosion resistance of standard and extra-low interstitial Ti–6Al–4V alloy were compared in three conditions of heat treatment. The heat treatments studied were the conventional solution-anneal-and-age and two duplex treatments which included controlled-rate cooling from above the beta transus temperature followed by the conventional treatment. The duplex treatments produced an acicular rather than an equiaxed alpha phase. Tensile properties were measured using unnotched sheet specimens. Similar specimens were used to evaluate stress-corrosion resistance at applied stress levels between 85 and 130 ksi. The specimens were subjected to N_2O_4 under a pressure of 250 psig and at temperatures of 105 and 160°F until failure occurred or a maximum of 30 days. Fracture toughness was evaluated qualitatively using precracked Charpy impact specimens. Author

N67-29201# Riv-Officine di Villar Perosa S.P.A., Turin (Italy).
ROLLING BEARINGS AND LUBRICANTS FOR HIGH-TEMPERATURE APPLICATIONS, PARTICULARLY IN TURBINE ENGINES
F. Colanzi *In* AGARD Gas Turbines 1966 p 413–431 (See N67-29181 16-28)

Experience in the field of aircraft turbine-engine bearings is briefly summarized. Tests carried out with high-temperature lubricants are reported, together with technical data on the manufacture and lubrication of aircraft turbine-engine bearings. Author

N67-29383*# National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.
STRESS CORROSION
Charles E. Cataldo *In its* Res. Achievements Rev., Vol. II 1966 p 7–14 (See N67-29381 16-17)

This article recounts briefly some of the more critical stress-corrosion failures that have been experienced at Marshall Space Flight Center and the corrective action taken. Some of the recent stress-corrosion studies are described and preliminary results tabulated. Specific problems described are the H-1 Engine LOX dome, the pneumatic line fitting sleeve problems and the more recent problem with wave springs used on MF-flared tube fittings. The use of nitric oxide in preventing stress–corrosion failures in titanium tanks is also discussed. Author

N67-29384*# National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.
EVALUATION OF MATERIALS BY NON-DESTRUCTIVE MEANS
Raymond L. Gause *In its* Res. Achievements Rev., Vol. II 1966 p 15–21 (See N67-29381 16-17)

The factors that result in a failure caused by stress corrosion are discussed and the various methods used to detect stress corrosion are mentioned. The role of nondestructive testing in solving the stress corrosion problem is outlined. Experimental techniques that may be capable of detecting and measuring stress corrosion and residual stress are discussed. In addition, equations are given for the ultrasonic wave propagation in an anisotropic medium. Author

N67-29600# Westinghouse Electric Corp., Pittsburgh, Pa. Research Labs.
INVESTIGATION OF SOLID LUBRICANTS FOR HELICOPTER TRANSMISSIONS Final Report, Jul. 1965–Nov. 1966
Paul H. Bowen Ft. Eustis, Va., Army Aviation Materiel Labs., Mar. 1967 81 p refs
(Contract DA-44-177-AMC-307(T))
(USAAVLABS-TR-67-4; Rept.-66-9B3-LUBER-R4; AD-650763) CFSTI: HC $3.00/MF $0.65

The feasibility of using solid lubricants in bearings and gears was demonstrated as a satisfactory method for preventing catastrophic failure and for providing emergency operation of helicopter transmissions in the event of an oil lubrication failure. Modified size-206 Conrad-type ball bearings with retainers of a glass reinforced polyimide, WRP-140, operated initially under a base line condition of oil lubrication for 40 hr. This was followed immediately by 0.5 hr of residual oil lubrication and 1.5 hr with no external lubrication at 14,000 rpm for various thrust loads of up to 800 lb without failure. Bearings with a silver alloy - Teflon composite, RB-HP-15 operated under similar oil and residual lubrication for 0.5 hr at loads of up to 450 lb before failure. A conventional 12 diametral pitch (DP) AISI 9310 gear set, using a 6-in. gear and a 2-in. pinion with a 2.5-in. idler of WRP-140, operated under base line conditions of oil lubrication for 40 hr at approximately 14,000 rpm and at a tooth load of 160 lb (640 lb/in. tooth width (ppi)). Similar gears with the same idler operated 0.5 hr with no external lubrication at a load of 1220 ppi (305 lb tooth load). With an RB-HP-15 idler, other gears were operated without lubrication for 0.5 hr at a load of 1220 ppi. Author (TAB)

N67-29713# Ohio State Univ. Research Foundation, Columbus.
EFFECTS OF SURFACE PREPARATION IN THE STRESS CORROSION CRACKING OF STAINLESS STEEL
R. W. Cochran and R. W. Staele Oct. 1966 117 p refs
(Contract AT(11-1)-1319)
(COO-1319-48) CFSTI: HC $3.00/MF $0.65

The effect of surface preparation on the incidence of stress corrosion cracking of Type-310 stainless steel was investigated. Wire specimens were used and exposed to boiling $MgCl_2$. Surfaces were prepared by mechanical polishing at three levels of roughness, chemical polishing, vacuum annealing, and electrochemical polishing. A wire range of mean-times-to-cracking was noted. Mean times differed by about a factor of five. Distribution of cracking times also varied about the mean values. Mechanically polished specimens cracked in shorter times than those chemically polished or vacuum annealed. The data were rationalized in the terms of probability of forming chemically active slip steps. Author (NSA)

N67-29852# Atomic Energy of Canada, Ltd., Chalk River (Ontario).
CHLORIDE STRESS CORROSION CRACKING IN THREADED 300 SERIES STAINLESS STEEL COMPONENTS
S. P. Gibson, W. Evans, and R. D. Watson May 1967 16 p refs Presented at Can. Nucl. Assoc. Ann. Conf., Montreal, May 1967
(AECL-2878) Available from Atomic Energy of Canada, Ltd., Chalk River: $0.50

Chloride stress corrosion cracking has caused costly failures of type 300 series, stainless steel, threaded components, in high temperature water systems. The source of chloride, in some instances, has been traced to chloro–fluoro organic compounds used as lubricants for assembling the threaded components. Author

N67-30089# College of Aeronautics, Cranfield (England). Dept. of Production and Industrial Administration.
THRUST AND STIFFNESS NOMOGRAMS FOR HYDROSTATIC BEARING CALCULATIONS
P. Cooke and A. J. Scarr Aug. 1966 10 p refs
(CoA-NOTE-M+P-13)

Consideration is given to the computation involved in arriving at suitable design parameters for hydrostatic lubrication. Expressions are given for two of the parameters, thrust and stiffness, and it is proposed that presentation of these formulas in the form of nomograms will aid the designer in solving design problems in hydrostatic lubrication more easily and efficiently. Methods for utilizing the nomograms are outlined, and examples are given of each. L.E.W.

N67-30105# Australian Aeronautical Research Committee, Melbourne. Dept. of Supply.
THE INITIATION AND INHIBITION OF CORROSION OF IRON IN NEUTRAL AQUEOUS SOLUTIONS
K. F. Lorking Sep. 1966 19 p refs
(ARL/MET-60)

It is proposed that when iron carrying its air formed oxide film is immersed in an aerated aqueous medium, the rate of solution of ferrous ions from the oxide film controls the process of film breakdown. When the solution rate of ferrous ion is slow, as in neutral benzoate, the current induced by reduction of dissolved oxygen is adequate to cause anodic passivation and prevent reductive dissolution of ferric ions in the oxide lattice. If ferrous ion

solution from the film is rapid, as in neutral sulphate, the current induced by reduction of dissolved oxygen is not adequate to cause passivation before areas of oxide free iron are exposed. In some solutions, such as neutral phosphate, electrochemical action alone is not sufficient to maintain passivity. Author

N67-30221 Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
FATIGUE PROPERTIES OF ALUMINUM ALLOY USED FOR HELICOPTER BLADES
Ye. V. Giatsintov, M. N. Stepnov, and V. P. Kogayev *In its* Aviation Technol. Inst. 13 Feb. 1967 p 27–46 refs (See N67-30219 17-17)

The results of investigations of fatigue strength under bending and extension–compression deformations, symmetric and asymmetric stress cycles, and corrosion are reported. The bending and tensile–compression tests were performed on both smooth and notched specimens, and the corrosion tests were carried out on smooth samples in distilled water and sea water. The data are graphed and tabulated, and it was concluded that: (1) Dispersion of life is increased with a decrease of stress. (2) Life and fatigue were reduced in a corrosive medium. (3) With an increase of corrosiveness and the degree of stress concentration, the dispersion of fatigue properties decreases. (4) The avial alloy studied is sensitive to asymmetry of the cycle. N.E.N.

N67-30282# Naval Research Lab., Washington, D. C.
REPORT OF NRL PROGRESS
Sep. 1966 54 p refs
(PB-173179)
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N67-30284# Naval Research Lab., Washington, D. C.
A MOTOR AND SOLID FILM LUBRICANT FOR VACUUM OPERATION AT CRYOGENIC TEMPERATURES
B. J. Zajac and M. Devine *In its* Rept. of NRL Progr. Sep. 1966 p 6–9 (See N67-30282 17-34)

Extended time operation of a size 11 synchronous motor at liquid nitrogen temperature and in vacuum has been made possible by use of a solid film lubricant. The lubricant is a mixture of molybdenum disulfide and graphite in a sodium silicate binder. It was applied to the ball bearings (commercially available SSR2A) that support the rotor. With the lubrication techniques and testing procedures used at the Naval Research Laboratory, an operating life of 900 running hours at 8000 rpm has been achieved. Operation at liquid helium temperature also has been demonstrated. Author

N67-30617# Air Force Systems Command, Wright-Patterson AFB, Ohio. Air Force Aero Propulsion Lab.
AIR FORCE AERO PROPULSION LABORATORY EFFORTS UNDER THE RTD PLAN FOR IMPROVED AIRCRAFT TURBINE ENGINE LUBRICANTS Technical Report, Sep. 1964–Oct. 1965
Kerry L. Berkey, George A. Beane, IV, and Leon J. De Brohun et al Jan. 1967 48 p
(AFAPL-TR-66-132; AD-651775) CFSTI: HC$3.00/MF$0.65

The program was conducted in three phases: investigation of more stringent MIL-L-7808 requirements, assessment of MIL-L-23699 oil capabilities, and investigation of advanced new materials. From the program, MIL-L-7808E was upgraded to MIL-L-007808F (USAF) by tightening existing requirements and adding new deposit forming and elastomer compatibility test requirements. MIL-L-7808 and MIL-L-23699 oils were compared and found to be comparable from a deposit forming standpoint. The decision was made to retain the MIL-L-7808 oils as the standard USAF aircraft turbine lubricant. Efforts were initiated to develop better oils than either the 23699 or existing 7808 oils. Author (TAB)

N67-30649# Army Weapons Command, Rock Island, Ill. Research and Engineering Div.
IMPROVEMENT OF THE ACCELERATED CONDENSATION APPARATUS FOR CORROSION PREVENTIVE EVALUATION Final Report, Jul. 1964–Jun. 1965
Van Y. S. Hong Feb. 1967 27 p refs
(RIA-67-306; AD-651451) CFSTI: HC$3.00/MF$0.65

In the evaluation of corrosion preventives the most critical analysis of any compound in this field is to determine its ability to protect. A current protection test employes the ASTM tentative Method D1748-62T. An improved version of this test method, the accelerated condensation apparatus (ACA) was studied. The improvement of its functional properties was investigated and recommended. Experimental results indicated a nylon cloth, selected from 14 types of fabric, showed positive improvement in the precision testing of the ACA. The study also uncovered several factors which affect the performance of the ACA. They are the test chamber temperature and the surface finish of the test specimen. Critical corrections for these factors were recommended to be incorporated into the standard test conditions for the ACA to provide optimum precision. Author (TAB)

N67-30794 Metaalinstituut TNO, Delft (Netherlands).
EFFECTS OF COLD PHOSPHATE TREATMENT ON THE BEHAVIOR OF PAINT COATINGS ON STEEL PROTECTED BY CATHODIC ACTION [ONDERZOEK NAAR DE INVLOED VAN FOSFATEERBEHANDELINGEN OP HET GEDRAG VAN VERFLAGEN OP STAAL BIJ KATHODISCHE BESCHERMING]
3 Apr. 1967 21 p In DUTCH
(TDCK-48258; C-67-279)

Tests were conducted to improve the corrosion resistance of steel plate used in ship hull construction. Particularly studied were measures to prepare damaged parts in the paint coatings for repair. Discussed is the removal of calcium and alkali deposits from such bared steel surfaces prior to painting, which customarily is accomplished by mechanical removal followed by a freshwater rinse and phosphate treatment. When subjected to cathodic action, blisters have frequently formed in the new coat of paint, and attention during the tests was focused on the cause of this formation of blisters. Fifteen sample groups of steel plates were variously prepared, treated, and finished, followed by immersion in artificial sea water with and without cathodic action for various lengths of time. Test arrangements are illustrated and explained, and results are presented in tables. Aside from its protective qualities, cathodic action was found to be a fast means for detecting small faults in

the paint coatings of steel plate. The results also prove that greater care must be taken in the preparation for coating and in the application of the paint to steel plate protected by cathodic action.
Transl. by K.W.

N67-30934*# Stanford Univ., Calif. Dept. of Materials Science.
THE MECHANISM OF HYDROGEN EMBRITTLEMENT IN STEEL
A. S. Tetelman Jul. 1967 63 p refs
(Grant NsG-622)
(NASA-CR-85771; SU-DMS-67-27; TR-7) CFSTI: HC $3.00/MF $0.65 CSCL 11F

The process of brittle fracture in structural materials can be separated into three stages; (1) crack nucleation, (2) slow crack growth, and (3) rapid, unstable fracture. Hydrogen embrittles steel by affecting the first two of these stages. In corroded, electrolytically charged, or thermally charged specimens, excess hydrogen precipitates at inclusions or carbides in molecular form, causing the initiation of voids or microcracks. The hydrogen pressure in these defects causes them to grow either by plastic deformation or by cleavage, depending on the intrinsic toughness of the particular steel and the shape of the nucleating particle. The size of the defects is determined by the spacing of the nucleating particles. In hot rolled materials, alignment of inclusions can be used to minimize hydrogen embrittlement. The effect of hydrogen concentration, applied stress, notch geometry, strength level, temperature, and microstructure on the incubation time for slow crack growth, the rate of slow crack growth, and the time to fail in a static test or the tensile ductility are considered. Crack growth in external environments, such as hydrogen gas, is also discussed briefly. Author

N67-30942# Atomic Energy of Canada, Ltd., Chalk River (Ontario).
U_3Si AS A NUCLEAR FUEL
G. H. Chalder, W. T. Bourns, M. A. Feraday, and J. Veeder May 1967 20 p refs
(AECL-2874) Available from Atomic Energy of Canada, Ltd., Chalk River: $0.50

The relevant properties of U_3Si are reviewed and results on aqueous corrosion and irradiation behavior are discussed. Economic studies are presented which indicate savings of 0.1–0.2 mill/kWh by substituting U_3Si for UO_2 as the fuel in CANDU type reactors. Author

N67-31373# United Kingdom Atomic Energy Authority, Springfields (England). Reactor Fuel Element Lab.
THE ADDITION OF YTTRIUM TO STAINLESS STEELS
P. D. Parsons 1967 7 p
(TRG-1345(S)) CFSTI: HC $3.00/MF $0.65

The influence of yttrium on the physical metallurgy of various iron-chromium and iron-nickel-chromium alloys is reviewed. The availability and the physical properties of yttrium are also discussed. The addition of ≈1% yttrium to 20–25-Nb stainless steel results in a marked improvement in grain stability below ≈1200°C, due to particles of an yttrium intermetallic phase. Above ≈1200°C grain growth is significant and the intermetallic phase is re-distributed around the grain boundaries. Prolonged heating at high temperatures in air results in oxidation of the yttrium phase and an apparent embrittlement of the alloy. Author

N67-31467# Societe d'Etudes, de Recherches et d'Applications pour l'Industrie, Brussels (Belgium).
STUDIES OF STEEL CORROSION IN HIGH TEMPERATURE WATER AND STEAM Quarterly Report, 1 Oct.–31 Dec. 1966
Dec. 1966 112 p Transl. into ENGLISH from French
(Contract EURATOM-087-1 TEEB(RD))
(EURAEC-1796; EUR-3336; QR-17) CFSTI: HC $3.00/MF $0.65

Developments in studies on corrosion of steels and other alloys by steam and water at high temperatures are reported. The materials studied included: stainless steel; steel; Zircaloy-2; Fe–Cr–Zr alloy; Inconel 600; and Incoloy 800. With regard to AISI Type-304 stainless steel, it was confirmed that excellent long-term behavior in superheated steam at 500°C calls for work-hardening to a depth of several tens of microns, such as may be produced by turning or milling. Microscopic examination of Inconel 600 and Incoloy 800 specimens oxidized in autoclaves in superheated steam at 600 and 700°C revealed very marked intergranular corrosion in the case of Inconel 600. Tests on a Zr–Cr–Fe alloy in superheated steam at 450°C showed that, after 3,000 hrs, electrolytic polishing is more favorable than pickling or preparing the surfaces mechanically. Author (NSA)

N67-31626*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
NASA RESEARCH ON MATERIALS APPLICABLE TO SUPERSONIC TRANSPORTS
Herbert F. Hardrath and George J. Heimerl *In its* Proc. of NASA Conf. on Supersonic-Transport Feasibility Studies and Supporting Res. Dec. 1963 p 349–362 ref (See N67-31606 18-02)

On the basis of studies on fatigue behavior, rate of fatigue crack propagation, residual static strength, and resistance to deterioration of properties due to prolonged exposure to temperature, no serious materials problems are anticipated, However, stress corrosion is found to be a potentially serious problem in titanium alloys in a hot salt environment and in stainless steels in an ambient environment. The Ti-8A1-1Mo–IV alloy is found to be generally superior to other contending materials in all respects studied except for salt stress corrosion in which respect it was poorer than all others. Author

N67-31867 Joint Publications Research Service, Washington, D. C.
CERTAIN PROBLEMS IN CONSTRUCTION OF MODELS FOR OBJECTS OF CONTROL
F. A. Ovsepyan *In its* Theory of Large Systems 21 Jun. 1967 p 12–17 refs (See N67-31865 18-19)

Mathematical expressions governing probability distribution functions were derived which are useful in certain problems concerning the wear of tools during the machining of parts, temperature variations in high speed cutting, and other similar problems. Mathematical expectation and dispersion as a function of time elapsed are examined. An example is considered in which the conditional density for a process of grinding the outside diameter of a ball bearing raceway on a centerless type automat of the automatic line of a ball bearing plant, is determined. The expression obtained is presented, and the distribution curve depicted. Results were checked with the aid of Kolmogorov's criterion, and indicate agreement between the theoretical distribution and the experimentally obtained data. L.S.

N67-32108# Massachusetts Inst. of Tech., Cambridge. Dept. of Chemical Engineering.
THE TOMS PHENOMENON—TURBULENT PIPE FLOW OF DILUTE POLYMER SOLUTIONS
Preetinder Singh Virk (Ph.D. Thesis) 15 Nov. 1966 454 p refs
(Contract Nonr-3963(10))
(AD-651767) CFSTI: HC $3.00/MF $0.65

Drag reduction caused by dilute, distilled water solutions of five polyethylene oxides, molecular weights from 80,000 to 6,000,000, in turbulent pipe flow was studied experimentally in 0.292 cm and 3.21 cm ID pipes. It was found that: The onset of drag reduction occurs at a well-defined wall shear stress related to the random coiling effective diameter of the polymer by the Onset Hypothesis. Laminar to turbulent transition is not, in general

delayed. The extent of drag reduction induced by a homologous series of polymers in a given pipe is a universal function of concentration, uniquely related to flow rate and molecular weight. The maximum drag reduction possible is limited by a universal asymptote that is independent of polymer and pipe diameter. In polymer solution, both the stagnation pressure attained with Pitot tubes and the heat transfer from cylinders in cross flow are drastically different from Newtonian; in general, both are lower. Author (TAB)

N67-32319# Mechanical Technology, Inc., Latham, N. Y.
A NUMERICAL SOLUTION OF THE ELASTOHYDRODYNAMIC FILM THICKNESS IN AN ELLIPTICAL CONTACT ELLIPTICAL CONTACT
Herbert S. Cheng May 1967 37 p refs
(Contract N00014-66-C0037)
(MTI-67-TR25; AD-652923) CFSTI: HC $3.00/MF $0.65

A numerical solution of the elastohydrodynamic film thickness in an elliptical contact is developed. The three dimensional Reynolds equation in the inlet region is solved by a finite difference method. The deformation contour in the inlet region is calculated according to the classical Hertz theory for elliptical contacts. Results are presented as side leakage film reduction factors, which are defined as the ratios of the film thickness of the finite contact to that calculated by a line contact theory based on the same maximum Hertz stress. The results obtained for b/a approaches infinity, which corresponds to a line contact, and for b/a = 1, which corresponds to a circular contact, agree with others. Comparison with experimental data indicates that the theory in the report predicts a film thickness slightly higher than those measured by the experiment. Author (TAB)

N67-32519# Miami Univ., Fla. Texas Univ., Austin.
THE MICROBIAL CORROSION OF IRON Final Report, Nov. 1958–Dec. 1964
Carl H. Oppenheimer Mar. 1967 18 p refs
(Contracts Nonr-375(10); Nonr-840(21))
(AD-653368) CFSTI: HC $3.00/MF $0.65

The investigation showed the potential and magnitude for microbial corresive effects on iron in marine environments. Aerobic and anaerobic corrosion cells can be developed by a wide variety of microorganisms. Aerobic corrosion is developed through metabolic oxygen consumption by bacteria on localized iron surfaces where organic food is present. Alternating bands of aerobic-anaerobic zones are formed in sediments by layering effects of deposition involving different amounts of organic materials. The layering does produce oxygen differential cells that are very corrosive. Anaerobic corrosion cells are produced by depolarization of the iron due to proton or hydrogen uptake. The activity is proportional to hydrogenase activity or to the presence of hydrogen acceptors in the area. Suitable tests involving weight loss of iron test coupons can be employed to show the corrosive nature of microorganisms in the environment. Author (TAB)

N67-32634*# Rocketdyne, Canoga Park, Calif.
INVESTIGATION OF BIAXIAL STRESS CORROSION IN TWO ALLOY Final Report, 29 Jun. 1966–28 May 1967
A. J. Jacobs 19 Jun. 1967 49 p refs
(Contract NAS9-6324)
(NASA-CR-65646; R-7102) CFSTI: HC $3.00/MF $0.65 CSCL 11F

The effect of a biaxial (1:1) stress state on the stress-corrosion resistance of 7075-T6 aluminum and 347 stainless steel was determined. Tubular specimens of these alloys were loaded in simple tension or were loaded in tension and pressurized to obtain the biaxial stress state. A total of 40 aluminum specimens, 20 short transverse and 20 long transverse, were subjected to alternate-immersion tests in a 3-1/2 percent NaCl solution at room temperature. The short transverse specimens were tested at 65 and 32.5 percent of yield strength, and the long transverse specimens at 80 and 65 percent of yield. Forty-two stainless steel specimens were continuously immersed in a constant boiling (309°F) aqueous solution of $MgCl_2$. These were investigated at 50 and 65 percent of their yield strength. Balanced biaxial loading compared with uniaxial loading is as follows in its effect on stress-corrosion life. The short transverse 7075-T6 specimens tended to survive somewhat longer under biaxial loading; however, there was no discernible effect in the case of long transverse specimens. A tendency was observed for the lifetime of 347 stainless steel specimens to be shortened under the application of biaxial stress. Author

N67-32736# Mechanical Technology, Inc., Latham, N. Y.
CALCULATION OF ELASTOHYDRODYNAMIC FILM THICKNESS IN HIGH SPEED ROLLING AND SLIDING CONTACTS
H. S. Cheng May 1967 106 p refs
(Contract N00014-66-C-0037)
(MTI-67TR24; AD-652924) CFSTI: HC $3.00/MF $0.65

A Grubin type inlet film thickness analysis including the full thermal effects is developed. The temperature distribution in the inlet region where the reverse flow exists is calculated by a repetitive forward and backward marching procedure. Results are obtained for wide ranges of loads, speeds and lubricant parameters. These cover extremely high speed ranges for which no results were available previously. The reduction of film thickness due to thermal effects is accounted by a thermal reduction factor, which is defined as the ratio of the actual film thickness to that calculated by isothermal theories. Design charts are presented in terms of the thermal reduction factors. A design procedure to calculate film thickness for high speed, heavily loaded contacts is developed and two numerical examples are included. Author (TAB)

N67-32893# Massachusetts Inst. of Tech., Cambridge. Instrumentation Lab.
A STUDY OF OIL CIRCULATION IN THE R4 SPIN-AXIS BEARING WITH SINTERED NYLON BALL RETAINER
Martin Roberts Dec. 1966 26 p refs
(Contract AF 33(615)-2243)
(E-2082; AD-652843)

A study was conducted on the circulation of lubricants in the R-4 spin-axis gyro bearing. The flow of lubricant was traced by incorporating 1% anthroquinone dye in the lubricant impregnated in an isolated portion of the sintered nylon retainer and periodically observing the color change of the undyed section as the lubricant was transported. Flow rates were determined for variations in speed, preload, bearing geometry, ambient pressure, lubricant viscosity and surface tension, retainer permeability, and the use of an antimigration barrier film. At 24,000 rpm and 7 pounds preload, an average circulation rate for Teresso V-78 was 45 micrograms/hour, which is equivalent to an average residence time of 2 hours on the metal raceways. The most important factor influencing circulation was the retainer permeability. Author (TAB)

N67-32969# Marine Engineering Lab., Annapolis, Md.
LUBRICATION OF TITANIUM STATE OF THE ART
Joanne R. Burns May 1967 21 p refs
(NSRDC-138/67; AD-652001) CFSTI: HC $3.00/MF $0.65

The advantages of using titanium in marine machinery are outlined, and the difficulty in lubricating machinery constructed of titanium is reviewed. A number of suggestions are given for possible research which might lead to the successful lubrication of titanium machinery components in a marine environment. TAB

N67-33014# Centre d'Etude de l'Energie Nucleaire, Mol (Belgium).
IN-PILE CORROSION OF NUCLEAR MATERIALS Quarterly Report, Jun. 1–Aug. 31, 1966

31 Aug. 1966 35 p refs
(Contract EURATOM-055-65-3 TEEB(RD))
(EURAEC-1784; EUR-3326; QR-5) CFSTI: HC $3.00/MF $0.65

In order to determine the effect of radiolysis of water on the electrochemical behavior of steel and Pt, systematic irradiation experiments with a Co source were carried out in acid solutions of ferrous and ferric ions, with additions of chlorides or alcohol or both. The radiolysis of these solutions was followed by recording the potential E_{Pt} of platinum versus an Ag/AgCl reference electrode during the after γ irradiation. Different types of (E_{Pt}-absorbed dose) diagrams were established, which showed potential increases and decreases, maxima and minima, depending on the experimental conditions. After thus following the radiolysis redox behavior, the open-circuit potentials of passivated and activated steel samples were measured as a function of time, (E_{SS}-time), in solutions irradiated up to particular points in the (E_{Pt}-dose) diagrams. A set of widely varying conditions in the solutions was thus obtained and the influence on the steel measured. Depending on these environmental conditions, activation of passive samples, passivation of active samples, and pitting phenomena were observed. Analyses of the irradiated solutions furnished information concerning the ions present at different irradiation stages. The strong reducing effect of organic impurities on, e.g., Fe^{3+} ions, during irradiation was demonstrated. These results together with literature data allowed an explanation of the main features of the (E_{Pt}-dose) curves: the platinum electrode functions either as an indicator for the available oxidation-reduction couples or as a hydrogen electrode, depending on the irradiation and "cooling" history of the solution. The (E_{SS}-time) curves were interpreted according to the aspect of the steel electrode after the test, which gave evidence of activation, passivation, and pitting. In addition, a start was made with potentiodynamic experiments which should at the end provide a complete explanation of the recorded variations of E_{SS} with time. Author (NSA)

N67-33019*# Mechanical Technology, Inc., Latham, N. Y.
ANALYSIS, DESIGN, AND PROTOTYPE DEVELOPMENT OF SQUEEZE-FILM BEARINGS FOR AB-5 GYRO. PHASE IV: DEVELOPMENT OF A CONICAL-BEARING, AXIAL EXCURSION PROTOTYPE Summary Report
F. K. Orcutt and C. H. T. Pan Apr. 1967 44 p refs
(Contract NAS8-11678)
(NASA-CR-87280; MTI-67TR30) CFSTI: HC $3.00/MF $0.65
CSCL 13I

Development of a preliminary prototype squeeze-film bearing system that would ultimately be suitable for gimbal axis support of an AB5 size gyro is discussed. For a given bearing surface geometry and mean-gap between surfaces, the bearing load capacity and stiffness increase with increased vibration amplitude. Or, stated another way, specified bearing load capacity and stiffness can be achieved with a larger mean gap if the vibratory motion amplitude is increased. For this reason, the effort to develop a squeeze-film bearing support centered on the development of the transducer system which provides the high-frequency vibratory motion of the bearing surfaces. Author

N67-33080# Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires.
CORROSION OF COPPER BY CHLORINE TRIFLUORIDE [LA CORROSION DU CUIVRE PAR LE TRIFLUORURE DE CHLORE]
Louis Vincent (Ph.D. Thesis—Paris Univ., 1965) 1966 57 p refs In FRENCH; ENGLISH summary
(CEA-R-2790)

The chlorine trifluoride was highly purified before use. The tests were carried out under different pressure and temperature conditions on copper samples of various purities, in particular a 99.999% copper in the form of mono-crystals. The kinetics showed reactions of the same order of magnitude as those obtained with elemetary fluorine. At atmospheric pressure there occurs formation of cupric fluoride and cuprous chloride, showing that it is not possible to consider ClF_3 simply as a fluorinating agent. At low pressures an unknown product was characterized. There are strong grounds for believing that it is unstable cuprous fluoride. A germination phenomenon was shown to exist indicating an analogy between the initial phases of fluorination and those of oxidation. Important effects resulting from the dissociation of the copper fluorides and the solubility of chlorine in this metal were demonstrated. Tests showed the considerable influence of the purity of the gas phase and of the nature of the reaction vessel walls on the rates of corrosion. Author

N67-33160# Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucléaires.
CORROSION IN THE PRESENCE OF A COMPLEXING AGENT APPLICATION TO THE CONTINUOUS DETERMINATION OF HYDROFLUORIC ACID IN THE ATMOSPHERE [CORROSION EN PRESENCE DE COMPLEXANT APPLICATION A LA DETERMINATION EN CONTINU DE L'ACIDE FLUORHYDRIQUE DAUS L'ATMOSPHERE]
Yves Chapron (M.S. Thesis) Oct. 1966 108 p refs In FRENCH; ENGLISH summary
(CEA-R-3031) CFSTI: HC $3.00/MF $0.65

After a presentation of the thermodynamics and kinetics involved during corrosion in the presence of a complexing agent, the first part of this report deals with the electrochemical properties of an aluminium electrode in the presence of fluoride solutions. Various physical and chemical parameters have been studied together with their influence on the aforementioned properties. From this first part are deduced the medium and the various parameters which lead to the maximum efficiency for the detection of fluorides by amperometry. The second part is an application of the results of the above work, which has made it possible to develop a cell having an original design. Its performances are described. They show that the cell has a greater sensitivity and a shorter response time than existing equipment. Author

N67-33201# Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.
CORROSION OF SUPERALLOYS AND REFRACTORY METALS IN HIGH TEMPERATURE FLOWING HELIUM
L. A. Charlot, R. A. Thiede, and R. E. Westerman Mar. 1967 28 p refs
(Contract AT(45-1)-1830)
(BNWL-SA-1137) CFSTI: HC $3.00/MF $0.65

The oxidation and evaporation behavior of Hanes 25 and Hastelloy X was determined under flowing He conditions in two high temperature loop systems at temperatures to 2100°F, linear flow velocities to 500 fps. and pressure of 200 psi. Oxidation rates of the superalloys did not appear to be affected by the presence of high-velocity He. Evaporation rates increased with gas flow rate and temperature, and decreased with inert gas overpressure. Refractory metal samples were exposed along with superalloy samples in the larger loop at 2100°F, 300 psi. It was found that clean loop conditions, with multiple start-ups after permitting access of air to the loop system, led to evaporative weight loss of *the superalloys, contamination and weight gain of the Nb and Ta* samples, and no significant evidence of attack on the Mo and W samples. Author (NSA)

N67-33212# Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucléaires.

NIOBIUM CORROSION FLOWING LIQUID SODIUM BETWEEN 400 AND 600°C [CORROSION DU NIOBIUM PAR LE SODIUM LIQUIDE EN CIRCULATION ENTRE 400 ET 600°C]

Jacques Sannier, Louis Champeix, Raymond Darras, and Willy Graff Oct. 1966 31 p refs In FRENCH; ENGLISH summary (CEA-R-3028) CFSTI: HC $3.00/MF $0.65

The corrosion of niobium and two of its alloys has been studied under temperature, rate of flow and purity conditions of liquid sodium similar to those likely to occur in a fast neutron reactor. The results obtained are discussed with reference to the following parameters: purification method used for the sodium, temperature, metallurgical condition of the structural metal. Generally speaking, an important role is played by the oxygen content of the liquid metal towards the corrosion of the niobium. Although the metal behaves very satisfactorily when a hot trap purification is used, it undergoes corrosion in the presence of sodium which has been purified only by a cold trap. Author

N67-33572# Air Force Systems Command, Wright-Patterson AFB, Ohio. Air Force Materials Lab.

LUBRICATION OF BEARING STEELS WITH ELECTRO-PLATED GOLD UNDER HEAVY LOADS Technical Report, Jan.–Sep. 1966

Riitsu Takagi and Tung Liu Mar. 1967 23 p refs (AFML-TR-67-61; AD-653974) CFSTI: HC $3.00/MF $0.65

The lubricating action of electroplated gold for 52100 steel and 440C stainless steel in sliding motion under a 150-pound load was examined with a modified Alpha Tester (Model LFW-1). The advantage of gold plating was found to be entirely that of wear prevention while the sliding friction coefficient was not altered significantly. The wear lives of thick films were much longer than for thin films. A 20 film had a wear life of 150,000 revolutions. Too thick a film results in fatigue failure at the gold-steel interface. Silver, copper, and two gold alloys were found to be far less effective than pure gold as a lubricant while nickel was not at all effective. The failure of the plated film was usually marked by a rapid increase in wear rate. With thick gold alloy films, wear debris in the form of thin sheets were obtained in addition to the fine particles normally found with metallic films. The appearance of the wear tracks indicated that the gold films underwent considerable plastic deformation. Author (TAB)

N67-33575# Naval Research Lab., Washington, D. C.

STRESS-CORROSION CRACKING RESISTANCE OF AN Ni 200 GRADE MARAGING STEEL BASE PLATE AND WELD

G. Sandoz and R. L. Newbegin Mar. 1967 13 p ref (NRL-MEMO-1772; AD-654161) CFSTI: HC $3.00/MF $0.65

The stress-corrosion cracking resistance in salt water of a welded 18Ni 200 grade maraging steel weldment was investigated. Unexpectedly, the weld metal was found to be more resistant to stress-corrosion cracking than the base plates. Author (TAB)

N67-33680# Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires.

PRELIMINARY STUDIES OF VANADIUM-BASE ALLOYS INTENDED FOR USE IN FABRICATION OF CANS FOR FAST REACTORS [ETUDES PRELIMINAIRES SUR LES ALLIAGES A BASE DE VANADIUM ENVISAGES POUR LA FABRICATION DE GAINES DE REACTEURS RAPIDES]

Madeleine Conte Mar. 1967 65 p refs In FRENCH (CEA-R-3152; EUR-3420.f)

Preliminary research has been carried out on a series of V-based alloys: V–0.5% Si; V–5% Ca; V–5% Mo; V–5% Nb; V–2% Zr; V–20% Ti; V–10% Al; V–10% Sn; and V–10% Ti for use as canning material in fast reactors. Transformation by forging at about 1000°C and rolling between 200°C and room temperature was satisfactory for all types of alloys except V–10% Sn and V–10% Al. The mechanical properties deduced from tensile strength tests carried out on alloy samples annealed 1 hour at 1050°C in a vacuum showed that, generally speaking, the addition elements led to an improvement in these properties as compared to those of pure V. After undergoing corrosion tests in a liquid Na loop purified by a cold trap, the alloys became brittle at room temperature. Only the V containing 20% Ti kept its plastic properties. These alloys were covered by a layer of VC. After undergoing treatment in a liquid Na loop purified by a hot trap, all the alloys kept their good mechanical characteristics. The surface layer with which they were covered was composed of two V carbides, VC and γVC, and a V sub-oxide, $VO_{0.9}$. Author (NSA)

N67-33687# Stanford Research Inst., Menlo Park, Calif.

HIGH RELIABILITY CONNECTIVE DEVICES Final Report, 1 Feb. 1964–31 Jul. 1966

Gunther Steinberg and Marvin Garrison Jun. 1967 164 p refs (Contract DA-36-039-AMC-03727(E)) (ECOM-03727-F; FR-5; AD-653847) CFSTI: HC $3.00/MF $0.65

The study established that electrical contacts can be successfully lubricated with solid organic compounds. Octadecylamine hydrochloride (ODA.HCl) is capable of providing durable low friction sliding on gold and is regarded as a type of solid organic compound that has inherent lubricity, can be sheared easily, but has the ability to support a load. For good durability, the lubricant must be present in reservoirs in the surface of the contacts. A contact lubricant decreases friction and attendant wear, and maintains the integrity of a protective gold (or other previous metals) platings. Preservation of this plating prevents gross corrosion in sliding contact tracks. Several methods for application of the ODA.HCl to commercial contacts were tested and methods for identifying the presence of the lubricant film were developed. Author (TAB)

N67-34024# General Electric Co., Schenectady, N. Y. Research and Development Center.

SOME PHYSICAL AND CHEMICAL PROPERTIES OF GRAIN BOUNDARIES

K. T. Aust Sept. 1966 22 p refs Presented at the Army Mater. Res. Conf. on Phys. and Chem. Characteristics of Surfaces and Interfaces, Raquette Lake, N. Y., 23–26 Aug. 1966 (Rept.-66-C-326)

Experimental data on the energy, migration, and corrosion behavior of grain boundaries in metals are presented. The interfacial energy data provide support for the coincidence lattice model of the structure of high-angle boundaries. The results of the boundary migration studies are in agreement with the theory of impurity-controlled motion proposed by Cahn. The work on grain-boundary corrosion demonstrates a useful approach to intergranular corrosion problems of commercial alloys. Author

N67-34120# Metaalinstituut TNO, Delft (Netherlands).

INVESTIGATION OF HOT PHOSPHATES [SPEURWERK WARM FOSFATEREN]

M. J. Reidt 31 May 1967 15 p In DUTCH (M-67-363; TDCK-46184C) CFSTI: HC $3.00/MF $0.65

Tests were conducted to evaluate several methods of treating relatively small steel parts with phosphate agents prior to painting. The phosphate and paint systems were applied to sample plates and evaluated for mechanical properties, corrosion inhibition, and compatibility. Detailed results of the tests are presented in tables, and the various systems are ranked in order of effectiveness. Transl. by K.W.

N67-34264# Reactive Metals, Inc., Niles, Ohio. Research and Development Dept.

THE INFLUENCE OF COMPOSITION AND HEAT TREATMENT ON THE AQUEOUS-STRESS CORROSION OF TITANIUM

S. R. Seagle, R. R. Seeley, and G. S. Hall 15 Mar. 1967 38 p refs

(Rept.-492)

Chemical composition and heat treatment were found to effect the aqueous-stress corrosion of titanium. Aluminum contents greater than 5 percent and oxygen contents greater than about 0.3 percent caused appreciable sensitivity to stress corrosion. The additions of beta-isomorphous type alloying elements, such as molybdenum, were beneficial for Ti–Al alloys but showed no improvement for Ti–O alloys. The amount of oxygen that could be tolerated was reduced substantially by the addition of aluminum. The heat-treatment temperature for maximum sensitivity to stress corrosion increased from 1000°F for Ti–6%Al alloys to 1200°F for Ti–8%Al alloys. This corresponds to about 150°F below the estimated Ti_3Al transus. The stress-corrosion resistance of Ti–6Al–4V alloy was reduced by long annealing times prior to exposure in the Ti_3Al region. Long annealing times also promoted stress corrosion in Ti–O alloys. Microscopic examination did not reveal significant changes with annealing time, which indicates the metallurgical factors affecting the stress-corrosion resistance are related to submicroscopic changes. Author

N67-34326# Oak Ridge National Lab., Tenn.

ELECTROCHEMICAL MEASUREMENTS ON CRYSTAL-BAR ZIRCONIUM IN OXYGENATED 0.05 M K_2SO_4 SOLUTIONS, BETWEEN 200° AND 240°C

H. S. Gadiyar [1967] 42 p refs

(Contract W-7405-ENG-26)

(ORNL-TM-1834) CFSTI: HC $3.00/MF $0.65

Electrochemical measurements on crystal-bar Zr in oxygenated 0.05M K_2SO_4 solution were made between 200 and 240°C, to measure the rates of corrosion and film growth at different temperatures. The rate–time plots obtained were analyzed for kinetics of film growth. Author (NSA)

N67-34394*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SLIDING FRICTION OF SOME MEMBERS OF THE PLATINUM METALS GROUP

Donald H. Buckley Washington, NASA, Sep. 1967 17 p refs

(NASA-TN-D-4152) CSCL 11F

The metals examined were ruthenium, rhodium, osmium, and iridium. Rhodium, ruthenium, and iridium were observed in sliding contact with themselves, while osmium was in sliding contact with iridium. The hexagonal metal ruthenium and the face-centered cubic metal rhodium were also made to slide in contact with polycrystalline aluminum oxide. The friction experiments were conducted at ambient pressures from 760 to 10^{-11} torr with a hemispherically tipped rider sliding on a rotating flat disk. Experiments were conducted at sliding velocities of 0.001 and 200 centimeters per second, at ambient temperatures from 20° to 500°C, and at loads from 50 to 100 grams. The results of this investigation show that the face-centered cubic platinum metals rhodium and iridium exhibit markedly higher friction coefficients at low ambient pressures than the close-packed hexagonal metals osmium and ruthenium. Stick-slip motion was observed with the face-centered cubic metal rhodium, but not with the hexagonal metal ruthenium under identical conditions. Surface contaminants had the greatest effect on the face-centered cubic metal rhodium. Friction data for the hexagonal metals osmium and ruthenium correlate with the fundamental relation between the friction coefficients of hexagonal metals and their c/a lattice ratios established in an earlier study. Author

N67-34486# United Kingdom Atomic Energy Authority, Risley (England). Reactor Group.

CONTRIBUTION TO THE STUDY OF HYDROGENATED AND OXYGENATED IMPURITIES IN LIQUID SODIUM

Gerard Naud 1966 50 p refs Transl. into ENGLISH of CEA-2583 (TRG-552(C); CEA-2583) CFSTI: HC $3.00/MF $0.65

Analytical methods for determining the levels of oxygen, hydrogen in the free state or in the form of hydride; total hydrogen; and sodium hydride, hydroxide and oxide impurities in liquid sodium are described. The kinetics of the reaction between hydrogen and liquid sodium between 150°C and 250°C was studied. Tests performed allowed the preparation of sodium samples with known levels of dissolved hydride or hydrogen, and also verified that, under experimental conditions, the variation in rate of reaction as a function of temperature follows the Arrhenius law with a corresponding activation energy of 16.5 kcal. It was also shown that the thermal decomposition of sodium hydride in liquid sodium and under a secondary dynamic vacuum is a first-order reaction. This property was demonstrated between 280°C and 310°C, and for hydrogen levels of the order of several ppm. In the reaction $NaOH+2Na \rightarrow Na_2O+NaH$, it was shown that the reaction appears to be of the first order, its threshold temperature being about 300°C. The parasitic evolution of gas in experiments when sodium is in contact with Pyrex glass was verified. Experiments showed that the attack of Pyrex glass by liquid sodium begins at about 150°C and is accompanied by evolution of hydrogen. Observation of the kinetics of the formation of hydrogen led to the formation of a hypothesis of a reaction between the sodium and the –OH groups which may be present in the glass. S.C.W.

N67-34538* International Lead Zinc Research Organization, New York.

INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION, RESEARCH DIGEST NO. 19, OCTOBER, 1966 TO APRIL, 1967. PART II—ZINC FOR CORROSION PROTECTION

Apr. 1967 31 p refs

Research and development of galvanizing processes and zinc rich paints are summarized. Problems connected with the hot dip galvanizing of high strength, low alloy steels, containing a high silicon content, are investigated. The constitution of the FeSi compound of the iron–silicon–zinc system was worked out. Vanadium and nickel additives to the galvanizing bath were found to be beneficial in pilot-scale tests. Clear protective coatings and porcelain enamels were investigated, along with the adhesive properties of paints and the effects of surface conditions. Research on potential and actual applications of zinc are reported, and include welding zinc-coated structurals, the mechanical behavior of galvanized bolts and structural joints galvanized coatings for elevated temperatures, galvanized steel reinforcement in concrete, and coating systems for sprayed zinc. Test results on organic and inorganic based paints and primers using zinc dust and on the dust size effects are summarized. N.E.N.

N67-34562# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

MODERN METHODS OF INVESTIGATING LIQUID FRICTION BEARINGS WORKING IN AGGRESSIVE MEDIA

L. I. Mamon and D. V. Galivets *In its* Chem. and Chem. Technol. Pt. II: Trans. 23 Dec. 1966 p 1–9 refs (See N67-34561 20-15)

The wear of metals in an aggressive medium was investigated using a special laboratory friction machine designated as the X2-M.

This machine permits carrying out investigations on the friction of a solid disk or metal, whereby, the sample is submerged in a liquid medium bath. The study of slide bearing operation was made in 92% sulfuric acid. It was established that the medium appears to be the basic factor reducing the surface hardness. Author

N67-34619# Marine Engineering Lab., Annapolis, Md.
BEARING MATERIALS FOR WATER LUBRICATION
Paul Lagally Mar. 1967 34 p refs
(MEL-103/67; AD-654177) CFSTI: HC $3.00/MF $0.65

Isotactic polybutene in contact with a bronze journal was investigated as a bearing material combination for water lubrication. development, and electroforming studies. High purity aluminum and was electroformed from a mixed ether bath of aluminum chloride and lithium aluminum hydride which showed potentially useful structural characteristics. The effects of current density bath impurities and various solvent and salt additions were studied. The aluminum electroforming process was scaled up and an aluminum paraboloid mirror, 30.5 centimeters, was electroformed to demonstrate the bath's practicability. Author

N67-34658*# Douglas Aircraft Co., Inc., Newport Beach, Calif. Astropower Lab.
STRESS CORROSION CRACKING OF TITANIUM ALLOYS AT AMBIENT TEMPERATURE IN AQUEOUS SOLUTIONS
Quarterly Progress Report, 1 Jan.–31 Mar. 1967
T. L. Mackay and C. B. Gilpin Mar. 1967 37 p refs
(Contract NAS7-488)
(NASA-CR-87432; SM-49105-Q3) CFSTI: HC $3.00/MF $0.65
CSCL 11F

Electron microautoradiograph studies of distribution of hydrogen by gas adsorption in titanium alloys showed: (1) a uniform distribution in Ti-13V-11Cr-3Al alloy, (2) a concentration of hydrogen in beta phase of Ti-8Al-1Mo-1V and Ti-6Al-4V alloys, and (3) a segregation of hydrogen at beta precipitates in alpha grain boundaries in Ti-5Al-2.5Sn. Stress corrosion tests in distilled water and in 3% NaCl aqueous solution at ambient temperature were made employing single edge notch specimens of Ti-5Al-2.5Sn, Ti-6Al-4V, Ti-8Al-1Mo-1V, and Ti-13V-11Cr-3Al. The beta alloy, Ti-13V-11Cr-3Al, was the only material which showed good resistance to stress corrosion cracking in these environments. Electron microfractographs of stress corrosion fractures of alpha and alpha–beta alloys showed a mixture of cleavage and ductile dimple rupture. Cleavage areas were larger in salt solution tests. Profiles of the stress corrosion fractures of Ti-5Al-2.5Sn and Ti-6Al-4V show beta phase does not exhibit ductility, and cleavage occurs at the alpha–beta phase boundaries in the stress corrosion fracture. The preferential segregation of hydrogen in the beta phase appears to be associated with this local cleavage. Author

N67-34679# IIT Research Inst., Chicago, Ill.
RESEARCH ON ZIRCALOY BRAZE ALLOY DEVELOPMENT
Quarterly Report, Jan. 1–Mar. 31, 1967
Deral E. Kizer and Z. P. Saperstein 17 Apr. 1967 15 p
(Contract AT(11-1)-578)
(IITRI-578-P29-11; EURAEC-1841) CFSTI: HC $3.00/MF $0.65

Brazing and corrosion test results are reported for 68 candidate braze alloys. A significant number of these are promising for brazing Zircaloy-clad fuel elements for pressurized water reactor application on the basis of the autoclave screening test results and some potentially promising on the basis of metallographic examination. Indications from metallographic analysis are that many of the promising systems, and some marginal ones, can be improved by appropriate thermal treatments during brazing for compositional modifications. Author (NSA)

N67-34696# Metallgesellschaft, A. G., Frankfurt am Main (West Germany).
INFLUENCE OF NEUTRON IRRADIATION ON THE MECHANICAL PROPERTIES AND THE CORROSION BEHAVIOR OF ZrNb3Sn1 AND ZIRCALOY-2
W. Spalthoff, E. Starke (G.K.S.S. mbH, Geesthacht), H. Richter, and W. Ruckdeschel Brussels, EURATOM, May 1967 37 p refs Presented at the Intern. Conf. on the Use of Zirconium Alloys in Nucl. Reactors, Pilsen, Czechoslovakia, 20–21 Oct. 1966
(Contract EURATOM-092-62-7RDD)
(EUR-3335.e; EURAEC-1795) CFSTI: HC $3.00/MF $0.65

Tensile and impact specimens were subjected to an integrated fast flux (E>1 MeV) of up to $4.5 \cdot 10^{19}$ n/cm^2 at 45°C in contact with the pool water. Corrosion specimens were irradiated in autoclaves in steam of 400°C and 100 at for up to 820 hours; in this case the maximum integrated fast flux (E>1 MeV) was $1.5 \cdot 10^{19}$ n/cm^2. For comparison, analogous tests without irradiation have been performed. The radiation caused an additional enhancement of the hydrogen uptake. The enhancement factors for the weight gains are not very well established, but there are indications that ZrNb3Sn1 is more corrosion-resistant under irradiation than Zircaloy-2. With both alloys the irradiation increases the yield strength and the ultimate tensile strength and decreases the elongation. The impact strength of ZrNb3Sn1 was increased but that of Zircaloy-2 was not essentially altered by the irradiation. The mechanical properties of both alloys reach saturation values with an integrated fast flux of about $3 \cdot 10^{19}$ n/cm^2. The recovery of radiation damage was investigated up to 450°C. While a 2 h-anneal at 300°C had no effect on the mechanical properties, a short anneal at 450°C was sufficient to eliminate the total irradiation-hardening. Author

N67-34717# Waterloo Univ. (Ontario). Dept. of Mechanical Engineering.
A HYDRODYNAMIC MODEL FOR COLD STRIP ROLLING
D. S. Bedi and M. J. Hillier [1967] 35 p refs CFSTI: HC $3.00/MF $0.65

The theory of rolling is modified to allow calculation of a hydrodynamic film thickness and viscous friction coefficient using Reynold's equation for the lubricant. Calculations are made for the case where the fluid film covers the arc of contact. The film thickness is assumed uniform and is determined by the principle of minimum rate of entropy production. It is shown that the apparent coefficient of friction varies significantly over the arc of contact. At small reductions the roll load tends to decrease with speed of rolling, while at high reductions the load tends to increase. The point of maximum roll pressure does not coincide with the neutral plane; and under certain rolling conditions there may be no maximum in the pressure over the arc of contact. Author

N67-34738*# Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.
ROLE OF CHLORIDE IN HOT SALT STRESS-CORROSION CRACKING OF TITANIUM-ALUMINUM ALLOYS
R. S. Ondrejcin, C. L. Selby, and S. P. Rideout Jul. 1967 16 p refs
(NASA Order R-124; Contract AT(07-2)-1)
(NASA-CR-87817; DP(NASA)-1118) CFSTI: HC $3.00/MF $0.65
CSCL 11F

Experimental evidence obtained by the electron microprobe, mass spectrometer, and radiotracers demonstrated that the role of chloride in hot salt stress-corrosion cracking of titanium-aluminum alloys is to form HCl through a pyrohydrolytic reaction between the salt, moisture retained in the salt deposit, and the protective oxide film on the metal. The HCl subsequently reacts with the metal surface to produce the metal chloride and hydrogen. Author

N67-34874 Joint Publications Research Service, Washington, D. C.
HUNGARIAN RESEARCH RESULTS IN DEVELOPMENT OF COOLING-LUBRICATING FLUIDS FOR METAL WORKING
Zolton Toth 13 Jul. 1967 25 p Transl. into ENGLISH from Gepgyartastechnol. (Budapest), v. 7, no. 5, May 1967 p 219–227
(JPRS-41817; TT-67-32449) CFSTI: $3.00

Research focusing on improving the properties of commercial mineral oil emulsions, the development and preparation of new emulsions for industrial metal working applications, and the development of control methods for measuring the properties of cooling and lubricating fluids; is reported. Significant findings of these studies are: (1) abietic acid emulsions, sulfonated castor oils, and non-ionic emulsions can be used industrially as cooling and lubricating fluids; (2) chloride, sulfur, and phosphorous additives in oils or in their aqueous mixtures can be used with good results under the most critical conditions; and (3) sulfide-containing fluids can be used for thread cutting, boraching, and long hole drilling with good results. Also reported is the development of a metal working inspection process which was used in the classification of emulsions under study. S.C.W.

N67-34966# Oak Ridge National Lab., Tenn. Reactor Chemistry Div.
COMPATIBILITY OF PYROLYTIC-CARBON COATED FUEL PARTICLES WITH WATER VAPOR
C. M. Blood and L. G. Overholser Nov. 1966 30 p refs
(Contract W-7405-ENG-26)
(ORNL-4014) CFSTI: HC $3.00/MF $0.65

The oxidation of various lots of coated fuel particles by water vapor was studied at 1000°C using He–water vapor mixtures having partial pressures of ≈4.5, 46, and 567 torr and a total pressure of 1 atm. Rates of reaction of water vapor with pyrolytic C coatings were determined from weight losses and, in a few instances, from flow rates and analyses of effluent gases. Surface area measurements of coated fuel particles were made before and after oxidation by water vapor. Incidence of failure of coatings was determined from the amount of U leached out of the oxidized coated fuel particles. Surface area development by oxidation with water vapor could not be correlated with reaction rates. The effects of partial pressure of water vapor on the reaction rates also were obscure. Experiments made in graphite containers indicated that graphite can protect the coated fuel particles from oxidation by water vapor. Photomicrographs of a number of oxidized fuel particles are included. Author (NSA)

N67-35303*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AEROSPACE RELATED TECHNOLOGY CONFERENCE FOR INDUSTRY AND COMMERCE
Washington, NASA, 25 May 1967 90 p
(NASA-TM-X-52345) CSCL 13H

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N67-35304*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MATERIALS
Harrison Allen, Jr. *In its* Aerospace Related Technol. Conf. for Ind. and Com. 25 May 1967 p 1–15 (See N67-35303 21-15)

The development of materials for extremely high and low temperatures, and the effects of these temperatures on mechanical and chemical properties are reviewed. The use of special silicate-base inorganic paints for corrosion resistance is mentioned. A multilayer insulation made of mylar plastic coated with a thin layer of aluminum is described, and aerospace and industrial applications are indicated. Improvements in reinforced composites are illustrated by fiber glass reinforced plastics and reinforcing with metal fibers and whiskers. Superalloy metallurgy and the use of tungsten alloys as die materials are summarized. N.E.N.

N67-35306*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MECHANICAL EQUIPMENT, BEARINGS, AND LUBRICATION
James E. Burnett *In its* Aerospace Related Technol. Conf. for Ind. and Com. 25 May 1967 p 35–52 (See N67-35303 21-15)

Bearing and lubrication technology for smaller, lighter, higher performance equipment, especially for high speed rotating machinery in hard vacuum, is briefly discussed. Ways of increasing life-expectancy of bearings and the influence of atomic structure on friction and wear properties are described. Both gas bearings and dry or solid lubricants are considered. A loss of steering control noticed by aircraft pilots on wet runways was investigated and found to be due to a hydroplaning effect. The low friction of fiberglass reinforced teflon, and other applications for rotating machinery are mentioned. N.E.N.

N67-35390# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
MOMENTS ORIGINATING FROM ERRORS IN THE FORM OF ROLLING SURFACES OF A BALL BEARING [MOMENTY, VOZNIKAYUSHCHIYE OT POGRESHNOSTI FORMY POVERKHNOSTEY KACHENIYA SHARIKOPODSHIPNIKA]
Ye. M. Rodionov 23 Dec. 1966 30 p refs Transl. into ENGLISH from Aviats. Tekhnol. Inst. Tr. "Tekhnol. i Konstruirovaniye Giropriborov" (Moscow), 1964 p 54–73
(FTD-HT-66-374; TT-67-62283; AD-655030)

The paper proposes, in a general form, a method for determining the translational displacements and additional moments of friction affecting rotation in ball bearings which are produced by translational motion (in addition to the vibration of fast moving shafts) of the rotating ring due to defects in the shape of the rolling surfaces of rings and balls as well as to the presence of a radial clearance, a bearing stiffness which varies with the angle of rotation, and other causes. These additional moments resisting the rotation of a ball bearing vary with the angle of rotation and, in contrast to the moments due to frictional forces, do not change their sign when reversing the bearing motion and do not decrease with vibration. The magnitude and character of the variation in these moments with the angle of rotation is closely related to the initial relative position of bearing parts as well as to the positions of balls as a result of vibration, clogging up, etc., and therefore these moments change when the relative position of the rings changes. The instability of the additional moments causes random errors in instruments, and unstable drift of gyroscopes which cannot be eliminated by balancing or correction. The translational displacements of the rotating ring and the additional moments are examined analytically for the case of an actual ball bearing. TAB

N67-35444 Glacier Metal Co., Ltd., Wembley (England).
THE DESIGN AND APPLICATION OF PLAIN BEARINGS FOR POWER TRANSMISSION MACHINERY
S. O. Rafique [1966] 20 p refs Presented at the B.G.M.A. Meeting, Coventry, 1 Nov. 1966

Basic considerations in bearing design are defined to show the limitations on the design specialist's capabilities, and the need for the power transmission engineer to delineate his requirements. It is pointed out that these areas of interaction pertain to the materials in contact with, or in close proximity to, the bearing such as the shaft, housing, and lubricant; to the steady or transient environment; and to the location and wall thickness of shells. Principles regarding bearing operations as they affect the user are enumerated for hydrodynamic lubrication, boundary lubrication, marine power transmission, electric motors and generators, rolling mill gear boxes, automotive gear boxes, and shaft linings and placements. M.G.J.

N67-35554*# Mechanical Technology, Inc., Latham, N. Y.
PERFORMANCE CHARACTERISTICS OF HERRINGBONE-GROOVED JOURNAL BEARINGS OPERATING AT HIGH ECCENTRICITY RATIOS AND WITH MISALIGNMENT
V. Castelli and J. H. Vohr Mar. 1967 39 p refs Sponsored in part by NASA
(Contract Nonr-3730(00))
(NASA-CR-88085; MTI-67TR15; AD-654580) CSCL 13I

The differential equation for the pressure distribution around a spiral-grooved journal bearing with compressible lubricant is solved by the numerical method of matrix influence coefficients for the case of arbitrary eccentricity and misalignment. Performance characteristics are presented for one particular bearing over the range 0 Lambda 20. Results are presented showing the restoring moment due to misalignment, the effect of L/D ratio at large eccentricity and the influence of eccentricity ratio on the optimum values of groove parameters for maximum radial stiffness. Comparison is made with experimental results. Author (TAB)

N67-35622# Naval Research Lab., Washington, D. C.
ARPA COUPLING PROGRAM ON STRESS-CORROSION CRACKING Quarterly Report
E. P. Dahlberg, ed. Apr. 1967 44 p refs
(Contracts Nonr-610(09); Nonr-760(31); N00014-66-C0365; ARPA Order 878)
(NRL-MEMO-1775; QR-2; AD-654711)

A progress report of the research investigations being carried out on the problem of stress-corrosion cracking of high strength materials is presented. Work concerning physical metallurgy, surface chemistry, fracture mechanics, and characterization tests and translation related to stress-corrosion cracking is described. The materials being studied include high strength steels, titanium alloys, and aluminum alloys. Abstracts of recently published reports are included. TAB

N67-35751*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY DETERMINATIONS OF TEMPERATURE LIMITATIONS OF ESTER, ETHER, AND HYDROCARBON BASE LUBRICANTS IN 25-MM BORE BALL BEARINGS
Erwin V. Zaretsky and William J. Anderson Washington, NASA, Sep. 1967 23 p refs
(NASA-TN-D-4146) CFSTI: HC $3.00/MF $0.65 CSCL 13I

Groups of 7205-size (25-mm bore) angular-contact ball bearings made from AISI M-1 steel were tested with eleven high-temperature lubricants. These lubricants were classified as polyphenyl ethers, esters, and hydrocarbons. Test conditions included outer-race temperatures of 250° to 600°F, speeds from 20,000 to 45,000 rpm, and maximum Hertz stresses of 189,000 to 347,000 psi in an SKF high-temperature bearing tester. Bearing AFBMA-rated (catalog) life was exceeded between 550° and 600°F with a synthetic paraffinic oil with an anti-wear additive under a low oxygen environment. The estimated bearing life with a diester base lubricant was less than half bearing AFBMA-rated (catalog) life in the temperature range of 450° and 550°F. The polyphenyl ethers exhibited the poorest life potential. Early fatigue spalling, wear, and surface distress occurred in the rolling-element components. The bearings run with the polyphenyl ethers did operate in an air environment; however, sludge formations occurred in both air and limited oxygen environments. Heavy coke deposits formed on bearings run with the ester lubricants at 500°F in a low oxygen environment. Gross lubricant degradation did not occur with the hydrocarbon lubricants run at 600°F in the low oxygen environment, although the fluid became blackened and some sludge deposits were noticed. Author

N67-35836# Brookhaven National Lab., Upton, N. Y.
THE U.S. PROGRAM ON CORROSION BY LIQUID Na
John R. Weeks [1966] 5 p
(Contract AT(30-2)-GEN-16)
(BNL-11265) CFSTI: HC $3.00/MF $0.65

Information of a preliminary nature on research programs conducted at three U. S. laboratories on corrosion of metals and alloys by liquid Na are given. Results of previous programs have been presented elsewhere and the current report discusses primarily the direction of effort in the U.S. NSA

N67-35986*# Aluminum Co. of America, New Kensington, Pa. Chemical Metallurgy Div.
INVESTIGATION OF THE STRESS-CORROSION CRACKING OF HIGH STRENGTH ALUMINUM ALLOYS Final Report, 6 May 1963–6 Oct. 1966
D. O. Sprowls, B. W. Lifka, D. G. Vandenburgh, R. L. Horst, and M. B. Shumaker 6 Oct. 1966 195 p refs
(Contract NAS8-5340)
(NASA-CR-88110) CSCL 11F

The necessity for developing reliabile stress corrosion test methods is discussed in relation to the selection of test procedures, specimens, loading methods, and environments that will produce accurate data on the failure mode, relative ratings of materials, and service performance. Several high strength aluminum alloys were investigated in various natural environments and laboratory media to determine their resistance to stress corrosion cracking. The 3.5% NaCl alternate immersion, and an acidified (pH 3) 5% NaCl intermittent spray are considered promising as accelerated test techniques. An evaluation of surface treatments and coatings showed that none offered complete protection. Procedures are detailed on an accelerated electrochemical test for evaluating stress corrosion resistance of 2219 alloy in less than an hour. Stress corrosion tests were also conducted on TIG welded butt joints of experimental high strength weldable alloys, loaded by bending and tension methods and exposed to several environments. It was found that direct tension loading caused more rapid failure of susceptible materials and at lower stresses than loading in bending. M.G.J.

N67-35990# Industrial Nucleonics Corp., Columbus, Ohio.
BETA RADIATION CORROSION DETECTION STUDY, PHASE II Final Report, Apr. 1966–31 May 1967
Albert J. Frasca, Charles H. Bemisderfer, and Charles E. Krause 31 May 1967 77 p refs
(Contract NOw-66-0440-c)
(Rept.-0-0603-FR; AD-654212)

The development of a portable gauge to demonstrate the use of beta radiation for corrosion detection was the primary goal of this program. The gauge was designed for detecting corrosion occurring at the interface between an aluminum substrate and an overlying organic protective coating. From this development program, appreciable insight was acquired for the development of a prototype gauge of this type. Test samples were fabricated from aluminum corrosion products (Al_2O_3) and used for calibration purposes. Laboratory data with these samples indicated that corrosion depths could be detected over a dynamic range of from 2 to

about 20 mils with the presently designed gauge. Also, it was quite that the gauge responded quite well to corrosion and pitting on the underside of thin metals such as aluminum and magnesium aircraft skins (skin thickness no greater than 20 mils for maximum sensitivity). The test results with calibrated surface corrosion samples and results of work concerning corrosion detection on the underside of aircraft skins are discussed. Also, photographs of the test results are given for surface and subsurface detection. Author (TAB)

N67-35995# National Research Council of Canada, Ottawa (Ontario).
DIVISION OF MECHANICAL ENGINEERING AND THE NATIONAL AERONAUTICAL ESTABLISHMENT Quarterly Bulletin, 1 Jan.–31 Mar. 1967
31 Mar. 1967 120 p refs
(DME/NAE-1967(1)) CFSTI: HC$3.00/MF$0.65

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1. THE DESIGN OF OPTIMAL EXTREMAL CONTROLLERS C. M. Woodside p 1–53 refs (See N67-35996 21-10)
2. AERIAL FOREST FIRE CONTROL D. G. Gould p 55–71 refs (See N67-35997 21-34)
3. LUBRICATING GREASES FOR AERONAUTICAL/AEROSPACE APPLICATIONS L. D. New p 73–78 refs (See N67-35998 21-15)

N67-35998# National Research Council of Canada, Ottawa (Ontario). Fuels and Lubricants Lab.
LUBRICATING GREASES FOR AERONAUTICAL/AEROSPACE APPLICATIONS
L. D. New *In its* Div. of Mech. Eng. and the Natl. Aero. Estab. 31 Mar. 1967 p 73–78 refs (See N67-35995 21-34)

Military specifications for lubricating greases in aerospace applications are briefly reviewed. Aircraft lubricant requirements are outlined and a few examples (lithium soaps, chiefly hydroxystearates sodium soap, treated natural clays, and substituted ureas) are mentioned to illustrate their variety and application. Operating conditions for high altitude aircraft, and the performance level demanded by today's conventional aircraft are included in a discussion of the response of the various fluid additives to improve performance. Research continues on the optimization of a lubricating fluid that will function efficiently under parameters of high and low temperature and which will be resistant to radiation. R.Ll.

N67-36041# TRW Systems Group, Redondo Beach, Calif.
RESEARCH INVESTIGATION OF CORROSION–RESISTANT MATERIALS FOR ELECTROCHEMICAL CELLS Final Report, Jan. 1966–Jan. 1967
Jan. 1967 97 p refs
(Contract DA-44-009-AMC-1452(T))
(TRW-05660-6002-R000; AD-654807)

The compatibility of highly corrosion-resistant metals and alloys with molten salt and hot phosphoric acid electrolyte systems was studied. Probes suitable for use with the electrical-resistance method in molten salt electrolytes were developed. The probes made from 304 and 316 stainless steels were tested in KCl and KCl-NaCl at temperatures of 820 C and 700 C, respectively. The probes of 316 stainless steel showed fair reproducibility in corrosion rates when the probes were prepared and tested under similar conditions. The electrical-resistance method was found to be equally applicable for evaluating material compatibility in hot, concentrated phosphoric acid. The pure metals Ta, Ni, and W, as well as Ni- and W-based alloys, were investigated. Ta and Ta-10W alloy exhibited corrosion rates less than 1 mpy. Pure W and Hs alloys, W-25Re and 40Mo-30Re-30W, were also resistant to concentrated phosphoric acid with corrosion rates between 1 to 6 mpy. The results also indicated the potential gains that can be achieved by exploring a large number of alloy system and its composition range. The diffusion block concept of preparing a large number of alloy combinations in a systematic manner was thus conceived and tested. Author (TAB)

N67-36043*# Pratt and Whitney Aircraft, East Hartford, Conn. Research Labs.
RESEARCH AND DEVELOPMENT OF HIGH-PERFORMANCE AXIAL-FLOW TURBOMACHINERY. VOLUME 3: DESIGN OF BACKUP GAS BEARINGS Final Report
J. T. McCabe, W. Shapiro, and T. Y. Chu Washington, NASA, Jun. 1967 250 p refs Prepared for Pratt and Whitney Aircraft
(Contract NAS3-4179)
(NASA-CR-802; PWA-2977, Vol. 3; F-82250) CSCL 13I

Detailed analysis and design data for a gas-lubricated bearing system consisting of two tilting-pad journal bearings with a spiral groove main thrust bearing for a 50,000 rpm Brayton cycle turbine-compressor are presented. Using the working fluid argon as the bearing lubricant, the principal objective was to provide a low friction bearing system of high reliability potential. Extensive steady-state data was generated so that sufficient information was available for system optimization. Having established a preliminary design based on steady-state consideration, a dynamical analysis was undertaken to examine the response of the rotor bearing system to the specified loading. A non-linear rotor journal bearing analysis was formulated, validated, and applied to finalize the preliminary design. Concurrently, the stability of the double acting thrust bearing was investigated. The proposed final design of the bearing system is predicted to meet all the required design specifications. Author

N67-36217*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE BEHAVIOR OF LUBRICATION SYSTEM COMPONENTS IN A VACUUM ENVIRONMENT
Donald H. Buckley *In* JPL 2d Aerospace Mech. Symp. 15 Aug. 1967 p 111–120 refs (See N67-36203 21-31)

Studies were conducted in a vacuum environment with various lubricants and the material to be lubricated. Evaporation experiments were conducted with various fluids, greases, inorganic compounds and soft metals. Friction, adhesion, and wear experiments were conducted with the various materials used in lubrication systems. The results of these studies indicated that, while relatively high rates of evaporation may be obtained for conventional oil and grease lubricants, these materials may be effectively utilized if concepts such as molecular flow seals are used to reduce evaporative losses. Further, for prolonged exposure to vacuum environment, many inorganic compounds and soft metal films have potential usefulness. In addition to evaporation losses, concern must be given to the type of lubricant that is used. With conventional lubricants, degassing of the fluids can present a problem. The results of sliding friction experiments in a vacuum environment indicate that there are basic metallic structures that have markedly superior friction wear and less tendency to adhere than bearing materials now conventionally used. Selective alloying of these metallic structures could be effectively used to prepare alloys specifically designed for use in lubrication mechanisms. Author

N67-36218*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
LUBRICATION AS PART OF TOTAL DESIGN
Francis J. Clauss *In* JPL 2d Aerospace Mech. Symp. 15 Aug. 1967 p 121–124 (See N67-36203 21-31)

Oils and greases, if properly selected, may solve many lubrication problems in space. Ball bearings must also be properly selected and must be protected from contamination. Operating temperatures should be accurately specified. For heavily loaded gears, MoS_2 films have been used successfully. Author

N67-36235* Stanford Research Inst., Menlo Park, Calif.
THE RESULTS OF LONG-TERM STORAGE TESTS FOR COMPATIBILITY OF NITROGEN TETROXIDE WITH VARIOUS SPACECRAFT MATERIALS
R. F. Muraca and J. S. Whittick 15 May 1967 104 p refs
Prepared for JPL *Its* Spec. Rept.-2
Contracts NAS7-100; JPL-951581)
NASA-CR-88121) CSCL 11F

The results of corrosion tests are reported for various metallic and ceramic specimens which were stored in sealed capsules with nitrogen tetroxide at 110°F for periods of 1-1/2 to 3 years. It was found that the least corroded materials are titanium alloys, iron alloys, cobalt alloys, some nickel alloys, tantalum, and alumina. Corroded materials are: molybdenum, magnesium, and some aluminum and nickel alloys. Chemical analysis of the nitrogen tetroxide included determination of water content by a new gas chromatographic procedure, of nitric oxide by a spectrophotometric method, and of chloride content and residue by standard analytical procedures. Examination of solid specimens included determination of change in weight, microphotographic studies of corroded or degraded surfaces, x-ray examination of corrosion products. Gages and fittings used with the storage capsules were also examined. The results of the chemical and metallurgical determinations are given in tabular form, supplemented by photographs of the surfaces of stored materials. Author

N67-36294# Oak Ridge National Lab., Tenn.
ELECTROCHEMICAL MEASUREMENTS ON NIOBIUM AT ELEVATED TEMPERATURES
H. S. Gadiyar, A. L. Bacarella, and A. L. Sutton 2 Jun. 1967 16 p refs
Contract W-7405-ENG-26)
ORNL-TM-1883) CFSTI: HC $3.00/MF $0.65

Preliminary studies on the electrochemistry of film formation on chemically polished Nb at 200°C are reported. During film formation in 0.05 M K_2SO_4 at 200°C, the rate steadily decreased first up to about 100 min and then became somewhat steady, changing from 1.0×10^{-6} to 5.5×10^{-7} amp/cm^2 from 110 to 5,600 min. It was found that film growth does not follow logarithmic, cubic, or hyperbolic sine function relations. The results indicated the formation of a porous film or film dissolution. Corrosion rates (at anodic potential +0.1 V) in 0.05 M H_2SO_4 decreased to about 3.2×10^{-6} amp/cm^2 after about 60 to 70 min exposure at 200°C, remained steady in the region for sometime up to around 300 min, and then again increased to values of 1×10^{-5} amp/cm^2 at 900 to 1000 min exposure. NSA

N67-36391*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF RECRYSTALLIZATION ON FRICTION PROPERTIES OF SOME METALS IN SINGLE-CRYSTAL AND POLYCRYSTALLINE FORM
Donald H. Buckley Washington, NASA, Sep. 1967 20 p refs
NASA-TN-D-4143) CFSTI: HC $3.00 CSCL 11F

An investigation was conducted with sliding friction experiments to determine the influence of recrystallization and texturing of various metals in sliding on friction coefficients. The metals examined in this investigation included copper, nickel, iron, tungsten, beryllium, and titanium. These metals were examined in their single-crystal and polycrystalline forms. The mating surface in sliding friction experiments was polycrystalline aluminum oxide. Experiments were conducted at a sliding velocity of 0.001 centimeter per second with no external heating of the specimens. A change in release of interface frictional energy to produce recrystallization for the various metals in sliding contact with polycrystalline aluminum oxide was achieved by changing the load. All experiments were conducted in a vacuum of 10^{-11} torr (1.33×10^{-9} N/m^2) with specimens which had been electron bombarded to clean their surfaces. The results of the investigation indicate that, at relatively modest loads, recrystallization and texturing will occur for some of the highest melting point metals. For example, tungsten, which has a recrystallization temperature of 1200°C, recrystallized and textured at the surface with a load of 3500 grams. The process of recrystallization and texturing produces very marked changes in friction coefficients. The higher the recrystallization temperature of a metal, the higher the load at a constant sliding velocity needed to produce recrystallization. Prior to recrystallization, all metals exhibited lower friction coefficients for single-crystal orientations than for the metals in their polycrystalline form. Author

N67-36462* Scientific Translation Service, La Canada, Calif.
CORROSION RESISTANCE OF Ti IN HOT CONCENTRATED CHLORIDE SOLUTIONS
Takaaki Shimose and A. Takamura Washington, NASA, Aug. 1967 11 p refs Transl. into ENGLISH from Nihon Kinzoku Gakkai-Shi, v. 29, no. 4, 1965 p 416–421
(Contract NASw-1496)
(NASA-TT-F-11177) CSCL 11F

An investigation was carried out on the corrosion resistance of titanium in hot concentrated chloride solutions, in order to study the cause of the unusual crevice corrosion encountered in chemical plants and to find preventive measures. The weight losses during the corrosion test and potentiostatic polarization were measured in various chloride solutions at or near the boiling temperatures. Stability of passivity on titanium was found to be dependent on the chloride concentration: the domain of passivity decreased with increase of the chloride and hydrogen ion concentrations, and the passivity became unstable gradually. And the tendency to activate from the passive state was accelerated by the elevation of temperature. For instance, while no corrosion was observed in the neutral 25% NaCl solution, a severe general corrosion occurred in the acidic 33% $AlCl_3$ solution, and even in the case of a neutral solution, pitting corrosion occurred in such high chloride concentration solutions as 61% $CaCl_2$ and 86% $ZnCl_2$ solutions. Author

N67-36550# United Kingdom Atomic Energy Authority, Risley (England). Reactor Group.
DEVELOPMENT WORK IN SUPPORT OF THE D.M.T.R. BOILING WATER LOOP
H. Middlebrook and A. C. F. Bramfitt *In its* In-Pile Irradiation Equipment and Tech. 1967 p 61–68 (See N67-36541 21-22)

Development aspects are described of a small-scale pilot loop operated to support the design and manufacture of an in-pile boiling water loop for water chemistry and corrosion problems associated with a ferritic steel reactor system. Author

N67-37044# Battelle Memorial Inst., Columbus, Ohio.
FORMATION OF ALKALI IRON SULFATES AND OTHER COMPOUNDS CAUSING CORROSION IN BOILERS AND GAS TURBINES Summary Report No. 2, Jan. 1–Jun. 30, 1967
30 Jun. 1967 57 p refs
(Contract NObs-94516)
(AD-656366)

The question of the relative importance of SO3 and of SO2 + O2 in flue gas in forming the complex sulfates that lead to corrosion has been answered by recent work with radioactive sulfur as a tracer. These test have shown that SO3 even in low concentrations is much more reactive. Additional measurements of the reaction of SO2 + O2 on catalytic surfaces now confirm that ample SO3 can be formed at the surface at a low gas velocity to account for the formation of the trisulfates. Such low gas velocities may exist on surfaces in boiler furnaces and gas turbines beneath layers of deposits. Trace amounts of trisulfates now can

be detected by an optical technique, and also an electrochemical device was developed that appears capable of indicating the onset of corrosion within a few minutes after establishing corrosive conditions. Author (TAB)

N67-37047# Tyco Labs., Inc., Waltham, Mass.
RESEARCH ON THE ELECTROCHEMICAL OXIDATION OF HEXANE AND ITS ISOMERS Semiannual Interim Report No. 2, 16 May–15 Nov. 1966
S. B. Brummer 15 Nov. 1966 47 p refs
(Contract DA-44-009-AMC-1408(T))
(AD-656496)

The mechanism of the adsorption and oxidation of C3H8 and n-C6H14 on smooth Pt electrodes from 12M H3PO4 at 130C was studied using potentiostatic step and galvanostatic pulse techniques. Initial adsorption of n-C6H14 occurs as virtually unchanged hydrocarbon at a diffusionally controlled rate. Subsequently, the adsorbed hydrocarbon reacts to form three types of adsorbed product - O-type, CH-alpha, and CH-beta. O-type n-C6H14 is similar to O-type C3H8 and to the product formed on Pt in the presence of CO2, reduced CO2. CH-beta, which has a low oxidation state and releases upwards of 4 electrons per site on oxidation, is unreactive both towards oxidation and towards reduction. It is probably a carbonaceous polymer. CH-alpha, which also has a low oxidation state, is relatively unreactive towards oxidation but can be readily reduced. It is probably a mixture of partially dehydrogenated alkyl radicals. The relation of these adsorbed species to the over-all hydrocarbon-to-CO2 reaction is discussed. TAB

N67-37140# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
CORROSION OF TITANIUM AND TITANIUM ALLOYS OF THE VT AND AT SERIES IN SULFURIC ACID SOLUTIONS CONTAINING NICKEL SULFATE [KORROZIYA TITANA I TITANOVYKH SPLAVOV SERIY YT I AT V RASTVORAKH SERNOY KISLOTY, SODERZHASHCHIKH SUL'FAT NIKELYA]
S. A. Nikolayeva and V. A. Zinov'yev *In its* Phys. Met. of Titanium 30 Dec. 1966 p 232–240 refs (See N67-37121 22-17)

The present paper considers the corrosion stability of sheet, bar and forged titanium in sulfuric acid. Bar titanium was found to have the highest resistance. It could be passivated at room temperature even in sulfuric acid with a concentration of 300 grams per liter. In studies on Ti alloys, the corrosion rate was measured by the weight loss of the samples in g/m^2.hr. Alloy components such as molybdenum and vanadium aid Ti passivation, but the presence of Al, Pb, Mg and Fe increases the corrosion rate of Ti. Chromium also aids passivation. Small additions of Ni promote corrosion of titanium, while further increases in the nickel concentration lead to a lower corrosion rate. In conclusion, the VT15, VT14, AT_2-1, AT_2-2, and AT_2-3 alloys show high corrosion resistance in strongly acidic solutions of nickel. The tests showed that the sulfate ion aids passivation of these alloys, and that nickel or copper ions generally stimulate corrosion. Author

N67-37141# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
CHEMICAL STABILITY OF TITANIUM IN SOME AGGRESSIVE MEDIA AND ITS APPLICATION FOR EQUIPMENT IN THE CHEMICAL INDUSTRY [KHIMICHESKAYA STOYKOST' TITANA V NEKOTORYKH AGRESSIVNYKH SREDAKH I OBLASTI YEGO PRIMENENIYA DLYA APPARATURY KHIMICHESKOY PROMYSHLENNOSTI]
S. M. Babitskaya, V. A. Strunkin, T. D. Zal'tsman, and Yu. I. Sorokin *In its* Phys. Met. of Titanium 30 Dec. 1966 p 241–249 refs (See N67-37121 22-17)

Tests with titanium showed strong corrosion in oxalic acid (100 mm/year, or the same as in 20% hydrochloric acid). Low stability of titanium was also noted in formic acid, tartaric acid and citric acid, as well as in mixtures of glacial acetic acid with acetic anhydride. Strong corrosion of titanium was observed in hot solutions of oxalic acid and tartaric acid, while the highly aggressive properties of citric acid are explained by the solubility of the compounds in water. These results indicate new possibilities for the use of titanium equipment where hydrochloric, hydrobromic, hydriodic and sulfuric acids containing free halogens participate in chemical reactions. Titanium tips are employed on thermocouples working in chlorination processes. Laboratory tests have shown the harmful action of alternating current on titanium in acid solutions, but a titanium bubbler has been working successfully in the production of chlorine. Author

N67-37142# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
CHEMICAL STABILITY OF TITANIUM IN HYDROHALIC ACIDS AND HALOIDS [KHIMICHESKAYA STOYKOST' TITANA V GALOIDOVODORODNYKH KISLOTAKH I GALOIDAKH]
Kh. L. Tseytlin, L. L. Fayngol'd, and V. A. Strunkin *In its* Phys. Met. of Titanium 30 Dec. 1966 p 250–267 refs (See N67-37121 22-17)

The present paper considers the effect of halogens on the chemical stability of titanium in halo acids. Titanium corrodes insignificantly in halo acids at room temperature, but at 90°C corrosion reaches tremendous proportions. In all cases, addition of halogens to hydrochloric and hydrobromic acids was found to lower the corrosion rate of titanium, although increasing the temperature lowered the protective capacity of the halogens. Chlorine, bromine and iodine decreased the corrosion of titanium to the same degree. Tests by the authors showed that VTI titanium sheets ignite in chlorine gas at room temperature after 24 hours. Strong corrosion was observed with iodine at 60°C. Other tests indicated that titanium reacts rapidly with both dry liquid bromine and moist bromine, although it has high stability in this respect about titanium. Test by the authors showed that almost all nitro compounds sharply lower the corrosion rate of titanium by hydrochloric acid up to 60°C. Author

N67-37143# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
INFLUENCE OF SODIUM NITRITE ON THE CORROSION OF TITANIUM IN HYDROCHLORIC AND SULFURIC ACIDS [VLIYANIYE NITRITA NATRIYA NA KORROZIYU TITANA SOLYANOY I SERNOY KISLOTAMI]
Yu. I. Sorokin and Kh. L. Tseytlin *In its* Phys. Met. of Titanium 30 Dec. 1966 p 268–279 refs (See N67-37121 22-17)

The effect of sodium nitrite on titanium corrosion by 20% HCl and H_2SO_4 was investigated using VTI-1 titanium sheets suspended in a thermostat with or without mixing. The tests indicated that titanium has satisfactory stability in 20% hydrochloric and sulfuric acids at 0 and 10°C. Increasing the temperature increased titanium corrosion in hydrochloric acid and 20% sulfuric acid. Addition of low concentrations of nitrite passivated the titanium in HCl and H_2SO_4 better than the addition of nitrous acid. This is due to the formation of nitro oxides by the nitrites. Addition of sodium nitrite passivates titanium in 20% HCl and H_2SO_4 at 20° and 60°C, while at 100°C it greatly lowers corrosion. The addition of sodium nitrite results in a positive potential on the titanium surface, satisfactory stability of the titanium being ensured in 20% HCl and H_2SO_4 with 0.01% $NaNO_2$ at 20°C and with 0.1% $NaNO_2$ at 60°C. Author

67-37251# Rock Island Arsenal Lab., Ill. Research and ngineering Div.
IICROBIAL-METAL CORROSION—LITERATURE REPORT
an Y. S. Hong Feb. 1967 33 p refs
IIA-67-534; AD-655274)

The importance of microorganisms in the corrosion process 'as illustrated as related to their broad distribution in nature and ieir longevity of existence on earth. A limited literature survey 'as made in the five areas of Microbial Corrosion. These areas re: historical background, mechanisms of microbial corrosion, iicroorganisms and the metals and alloys they attack, preventive ieasures to counteract this corrosion, and examples of microbial orrosion in military equipment. A brief discussion of each area 'as made, and also a future research program was suggested in solving some of the problems found in these areas. TAB

167-37370*# General Electric Co., Cincinnati, Ohio. Flight ropulsion Div.
EARING FATIGUE INVESTIGATION Final Report
. N. Bamberger 15 Sep. 1967 203 p refs
Contract NAS3-7261)
NASA-CR-72290; R67FPD309) CFSTI: HC $3.00/MF $0.65 SCL 13I

A research program to establish the feasibility of operating irge diameter rolling element bearings at 600F under conditions f load and speed approximating those experienced by main shaft earings in jet engines is discussed. Two bearing materials and iree advanced lubricants were investigated. The lubricants were: nthetic paraffinic oil, polymeric perfluorinated fluid, inhibited, mixed omeric 5-ring polyphenyl ether 5P4E. Over 54,000 hours of earing testing were accumulated. Additionally, a large number of ench type rolling contact fatigue tests were conducted, as well s extensive lubricant and metallurgical analysis. The data shows that ie paraffinic oil will provide satisfactory hydrodynamic lubrication t 600F in an inerted atmosphere. The polyphenyl ether and the olymeric fluid are marginal in their lubricating capability at the 00F temperature. Bearing failures at 600F are similar to those bserved at lower temperatures. Author

167-37407*# SKF Industries, Inc., King of Prussia, Pa. ngineering and Research Center.
XTREME TEMPERATURE AEROSPACE BEARING-LUBRI-ATION SYSTEMS Final Report, Nov. 22, 1965–Apr. 30, 967
. B. Sibley and L. A. Peacock 20 May 1967 55 p refs
Contract NAS3-7912)
NASA-CR-72292; SKF-AL67TO63) CSCL 13I

A group of 30 angular-contact 24-mm bore ball bearings nade of vacuum-melted high temperature tool steels were life ested successfully at 600°F outer-ring temperature with a synthetic ydrocarbon lubricant having an anti-wear additive. No failures ccurred from fatigue spalling of the balls or ring tracks in the 30 earings tested to a time-up life of 180 hours. Three bearings ailed by smearing (gross metal transfer on the balls and grooves lue to lubrication-related thermal instabilities) at lives of 18 to 8.9 hours. Another group of 14 bearings were tested in a imilar manner except that the test bearings were treated with a lack-oxide surface coating known to reduce lubrication-related ailures of bearings made of 52100 or M-50 type bearing steels. All f these tests were terminated by smearing or lubrication-related palling failure at lives of 0.2 to 9.3 hours. Author

N67-37548# Army Weapons Command, Rock Island, Ill. Research and Engineering Div.
GREASES—EFFECTS OF COMPOSITION AND SHEAR RATE ON MECHANICAL STABILITY
Robert L. Young Apr. 1967 24 p refs
RIA-67-1075; AD-655275)

Seventeen greases were shear worked at ambient temperatures by three different shear methods. The approximate shear rates of these methods were 20/sec., 450/sec., and 10,000/sec. The breakdown of the greases was evaluated by consistency changes as determined by the 1/4 scale worked penetration, ASTM Federal Test Method D-1403. It was found that the greases made with synthetic thickeners were usually more shear stable than those made with soap base thickeners. In a majority of greases the higher the rate of shear, the greater the breakdown. Author (TAB)

N67-37576* Scientific Translation Service, La Canada, Calif.
EFFECT OF INTERSTITIAL ELEMENTS AND IRON ON CORROSION RESISTANCE OF COMMERCIALLY PURE TITANIUM IN HYDROCHLORIC ACID AND SULFURIC ACID
Shujiro Suzuki Washington, NASA, Oct. 1967 11 p refs
Transl. into ENGLISH from Boshoku Gijetsu, v. 15, no. 6, Jun. 1966 p 12–18
(Contract NASw-1496)
(NASA-TT-F-11279) CSCL 11F

The effect of interstitial elements and iron on corrosion resistance of commercially pure titanium in hydrochloric acid and sulfuric acid at room temperature and on their boiling temperatures was investigated. The results were summarized as follows: (1) Oxygen, nitrogen, or carbon, up to 0.5%, improved the corrosion resistance of commercially pure titanium in hydrochloric acid and sulfuric acid. (2) Addition of iron to the specimens containing oxygen, nitrogen, or carbon showed a tendency to decrease corrosion resistance. (3) The specimen containing a semi-transformed structure was inferior to equiaxed α structure as to corrosion resistance. (4) Anodic polarization was measured in hydrochloric acid by a Gerischer type of potentiostat. The above mentioned results were confirmed from the standpoint of anodic polarization. Author

N67-37582# Naval Ship Research and Development Center, Annapolis, Md.
STRESS–CORROSION STUDIES OF ALUMINUM ALLOY 5456-H321 IN SEAWATER
George A. Wacker Jul. 1967 27 p refs
(NSRDC-2436; AD-656573)

The stress-corrosion susceptibility of Aluminum Alloy 5456 in the H321 temper was investigated as a function of longitudinal, long transverse, and short transverse plate orientations. The alloy was found to be subject to pitting attack but immune to stress-corrosion cracking in flowing seawater at ambient temperature. Author (TAB)

N67-37631# *United Kingdom Atomic Energy Authority, Harwell* (England). Chemistry Div.
STRESS CORROSION OF IRRADIATED TYPE 316 STAINLESS STEEL
C. F. Knights Jun. 1967 11 p refs
(AERE-M-1899) HMSO: 1s 9d

The investigation of the effect of irradiation with mixed thermal and fast neutrons on the susceptibility of type-316 stainless steel to stress corrosion cracking in $MgCl_2$ solution has been extended to stresses below 5,000 lb/in^2. There is a critical applied stress below which the time to failure is very dependent on stress. Fast neutron damage to the metal appears to be responsible for the enhanced susceptibility to stress corrosion cracking. Author

N67-37733# Argonne National Lab., Ill.
CORROSION OF ALUMINUM ALLOYS BY FLOWING HIGH-TEMPERATURE WATER
J. E. Draley and W. E. Ruther Jan. 1967 20 p refs
(Contract W-31-109-ENG-38)
(ANL-7227; ANL-6677; ANL-6868; ANL-7000; ANL-7155) CFSTI: HC $3.00/MF $0.65

A hypothesis is proposed relating the increased corrosion of Al alloys in rapidly flowing water (at high temperature) to precipitating colloidal corrosion products in the stream. A series of experiments showed that colloidal graphite and colloidal hydrated Al_2O_3 could significantly reduce the corrosion rate in 260°C water flowing at 7 m/sec. Corrosion rates approximating those obtained in static tests were achieved in the hydrated Al_2O_3 colloid solution. The total corrosion for one week in flowing 260°C water varied with small applied currents, increasing when the sample was made the cathode and decreasing when made the anode. AsO_3 solution gave promise of being an effective corrosion inhibitor for high-temperature corrosion of Al in flowing water. A model of Al-corrosion mechanism is discussed. Author (NSA)

N67-37799*# Mechanical Technology, Inc., Latham, N. Y.
A SEMI-IMPLICIT NUMERICAL METHOD FOR TREATING THE TIME TRANSIENT GAS LUBRICATION EQUATION
Vittorio Castelli and Charles H. Stevenson Mar. 1967 21 p refs Sponsored in part by NASA and AEC
(Contract Nonr-3730(00))
(NASA-CR-88639; MTI-67TR14) CFSTI: HC $3.00/MF $0.65 CSCL 13I

This report presents a numerical method for treating the time transient Reynolds equation which has the numerical stability properties of implicit schemes and the speed of execution of explicit methods. These advantages make this method quite suitable for both steady-state and transient calculations. Author

N67-37932# Babcock and Wilcox Co., Lynchburg, Va. Research and Development Div.
CORROSION AND HYDRIDING OF ZIRCALOY Quarterly Technical Progress Report, Jan. 1–Mar. 31, 1967
May 1967 28 p refs
(Contract AT(30-1)-3765)
(BAW-3765-2; EURAEC-1856; QTPR-2) CFSTI: HC $3.00/MF $0.65

Operational limitations for Zircaloy fuel cladding were studied. The program is divided into two tasks: corrosion and hydriding tests of Zircaloy under heat-transfer conditions to determine the quantity of H absorbed during service, and mechanical-property tests of hydrided Zircaloy to determine the effect of H on cladding properties. The corrosion and hydriding test loop was operated initially on February 22, 1967. Specimen insertion started March 3, 1967, and was completed March 9, 1967. The calculated surface heat flux on all specimens is 600,000 Btu/hr-ft^2. Precorroding of specimens in 800°F, 500-psig steam to apply an oxide film and to introduce H_2 to simulate the condition of cladding at the end of core life began late in the first quarter. Test specimen data indicated that a 120-day exposure would produce the desired end-of-life conditions. After 90 days' exposure, the nine heat transfer specimens and their associated isothermal specimens were removed for an interim examination. All of the heat transfer specimens had undergone excessive oxidation and were no longer usable. Other methods of accelerating oxidation and hydriding are being investigated, so that the end-of-life specimens can be prepared without the risk of losing the specimens through excessive oxidation. (Additional specimens are being prepared to replace the lost specimens.) Hydriding of annealed and cold-worked tensile and burst test specimens was completed through 350-ppM H_2 content. Room-temperature tensile testing of these specimens was completed. Elevated-temperature tensile testing of annealed and cold-worked specimens was initiated and tests were completed through 650°F. A preliminary series of tests was performed to determine the dwell time necessary before testing to yield consistent tensile strength data. It was found that testing a specimen as soon as it reached test temperature yielded variable and inconsistent results, whereas holding the specimens at test temperature for at least 30 min resulted in consistent and reproducible data. Author (NSA)

N67-38115# Mechanical Technology, Inc., Latham, N. Y.
REVIEW OF FAILURE MECHANISMS IN HIGHLY LOADED ROLLING AND SLIDING CONTACTS
A. J. Smalley, S. F. Murray, H. Christensen, and H. S. Cheng May 1967 70 p refs
(Contract N00014-66-0-0037)
(MTI-67TR23; AD-657337)

The failure modes of fatigue and scoring in highly loaded contacts are analyzed. Existing theories by which their onset may be predicted are critically examined, and the relationship between these failure modes and the phenomenon of elastohydrodynamic lubrication is shown. The possible modifying influence of microelastohydrodynamic occurrences is pointed out and a method of analyzing such occurrences is proposed. The protecting influence of boundary lubrication effects is also demonstrated, and mechanisms for satisfactory performance and failure under the influence of this phenomenon are put forward. Author (TAB)

N67-38141*# Westinghouse Electric Corp., Pittsburgh, Pa.
CORROSION OF ALUMINUM IN WATER
D. N. Fultonberg Washington, NASA, Oct. 1967 82 p refs
(Contract NAS3-5215)
(NASA-CR-899; WCAP-7029) CFSTI: HC $3.00/MF $0.65 CSCL 18J

Tests were performed in autoclave systems and in pumped loops in order to determine the corrosion and hydrogen generation of aluminum when subjected to conditions typical of those anticipated in a Tungsten Water-Moderated Reactor (TWMR). These tests, the equipment used, and the results obtained are discussed. It was concluded that the hydrogen generation could be excessive under certain conditions and that a broader program would be necessary in order to predict it with some confidence. Author

N67-38172# Naval Research Lab., Washington, D. C.
MARINE CORROSION STUDIES: THE ELECTROCHEMICAL CHARACTERISTICS OF SEVERAL PROPRIETARY ALUMINUM GALVANIC-ANODE MATERIALS IN SEA WATER Interim Report
T. J. Lennox, Jr., M. H. Peterson, and R. E. Goover May 1967 43 p refs
(NRL-MR-1792; AD-656899)

A series of experiments is described which was designed to obtain the electrochemical efficiency, electrochemical potential, and current output versus time data for five proprietary aluminum alloys using full-size anodes in sea water under conditions which approach those encountered in service. High and dependable electrochemical efficiency, sustained current output versus time characteristics, and elimination of inherently high resistance between cast-in steel cores and the anode metal must be realized before aluminum anodes can be considered for general Navy use. TAB

N67-38175# Naval Radiological Defense Lab., San Francisco, Calif.
CORROSION STUDIES OF HAYNES 25 ALLOY IN SEAWATER USING ELECTROCHEMICAL TECHNIQUES
Donald A. Kubose and Herman I. Cordova 16 May 1967 31 p refs
(Contract AT(49-5)-2084)
(USNRDL-TR-67-64; AD-656897)

Electrochemical corrosion rate measurements were made on uncoated, emissively coated and thermally shocked and uncoated specimens of Haynes 25 alloy in seawater at room temperature and 90C. The corrosion rates of the emissively coated specimens were about an order of magnitude higher than those of the uncoated specimens. No significant difference between the corrosion rates measured at room temperature and at 90C was observed for either the uncoated or the emissively coated specimens. Thermal shocking of uncoated specimens (by quenching from 500C to room temperature) did not increase their corrosion rates. The

corrosion rates observed were on the order of 0.003 mils per year (mpy) for the uncoated and the thermally shocked uncoated specimens and 0.04 mpy for the emissively coated specimens. Author (TAB)

N67-38347*# Ohio River Div. Labs., Cincinnati.
FULL SCALE CRAWLER BELT SHOE TESTS—SURFACE EFFECTS
Apr. 1967 61 p refs
(NASA Order CC-15162)
(NASA-CR-88984; TM-2-64) CFSTI: HC $3.00/MF $0.65 CSCL 22D

A qualitative evaluation is made of the materials and methods being considered for remedial construction of the crawler way pavements for Launch Pads A and B of Lunar Launch Complex 39 at the John F. Kennedy Space Center. The materials and surfacing are described and are evaluated through simulated loading with a full scale crawler belt shoe from the crawler transporter. The results of these studies have indicated the most feasible of the surfacing materials evaluated both from the standpoint of structural stability and desirable friction characteristics when used with a special lubricant. Further full scale studies of this surfacing material are recommended for tests under the operation of the fully loaded crawler transporter. Author

N67-38350*# Materials Research Lab., Inc., Richton Park, Ill.
ELEVATED TEMPERATURE STRESS CORROSION OF HIGH STRENGTH SHEET MATERIALS IN THE PRESENCE OF STRESS CONCENTRATORS Final Report
R. G. Lingwall and E. J. Ripling Aug. 1967 35 p refs
(Contract NASr-50)
(NASA-CR-88979) CFSTI: HC $3.00/MF $0.65 CSCL 11F

Experiments on the electrochemical aspects of hot salt cracking of titanium alloys suggest that cracking occurs due to the formation of an oxygen differential cell. Cracking occurs only at the cathode of the cell, and can be prevented by impressing an anodic potential on the stressed titanium. Hydrogen produced at the cathode where it enters the metal is deduced to be the basic cracking agent. Author

N67-38485# Bell Telephone Labs., Inc., Reading, Pa.
PREVENTION OF STRESS-CORROSION FAILURE IN IRON–NICKEL–COBALT ALLOY SEMICONDUCTOR DEVICE LEADS
M. J. Elkind and H. E. Hughes *In* RADC Phys. of Failure in Electron., Vol. 5 Jun. 1967 p 477–495 refs (See N67-38461 23-09)

The susceptibility to stress corrosion cracking of the iron–nickel–cobalt alloy, commonly used for semiconductor device leads, is discussed. The work reported confirms that stress corrosion cracking of this alloy can occur very rapidly in the presence of a combination of condensed atmospheric moisture and stress. Detection of this phenomenon by accelerated tests is the basis for evaluating and introducing corrective measures to surmount this failure mechanism. Factors intensifying the alloy's susceptibility to stress corrosion when used as semiconductor encapsulation leads have been identified. Author

N67-38574# General Electric Co., Pleasanton, Calif. Nuclear Technology Dept.
STAINLESS STEEL FAILURE INVESTIGATION PROGRAM Quarterly Report, Jul. 1–Oct. 31, 1966
R. N. Duncan, comp. Dec. 1966 58 p refs
(Contract AT(04-3)-189)
(GEAP-5281; QR-6; EURAEC-1831) CFSTI: HC $3.00/MF $0.65

Results of corrosion tests on high-purity stainless steels, with minor additions of impurities, conducted in solutions of HNO_3+Cr^{+6}, and in $FeCl_2$ are reported. Specimens of types 348 and 304 stainless steel cladding were evaluated for susceptibility to intergranular attack before and after irradiation. Research on effects of applied stresses on fuel cladding as related to intergranular corrosion attack indicates that low-cycle fatigue is not a significant factor in intergranular failure mechanisms, that corrosion film material is not propagated into the cladding by cyclic flexing, but that surface strains of 0.006 in./in. can be related to formation or presence of integranular attack in irradiated unsensitized type-304 stainless steel after operation in a BWR environment. NSA

N67-38904# Japan Atomic Energy Research Inst., Tokyo.
LIQUID SODIUM TECHNOLOGY DEVELOPMENT. I: TEST LOOPS, PURIFICATION METHODS, AND SUPPLEMENTARY TECHNIQUES
Kazuo Furukawa, Ken Yamamoto, Isao Nihei, and Yae Iguchi Nov. 1965 32 p refs
(JAERI-1129)

The initial results of the development program of liquid Na loops and associated technology are reported for the period 1957 to 1965. Test loops such as corrosion test loop, purification test loop, and mother and daughter test loop system, and their operating experiences are described. In mother and daughter test loop system, various tests are made with daughter test loops, using Na with given contents of impurities which are controlled in the mother loop. Then, the results of development and operating procedures are described for the purification system (cold trap, cold finger, and hot trap). The first model of the cold trap has a Na-oxide removal-capacity of 1.3 kg/30 l. Improvements to this trap are proposed for increasing the capacity to three times the initial one by controlling internal temperature distribution. The results of corrosion and carburization tests are also shown. In the tests, emphasis was placed on austenitic stainless steels (304, 316, 347 S.S.), followed by Cr–Mo steels and refractory metals (Nb, Ta, Mo, Zr, and Ti). The analytical data and behaviors are also described for O, C, etc. in Na. Author (NSA)

N67-38943* Catalyst Research Corp., Baltimore, Md.
TEST EVALUATION OF FUEL CELL CATALYSTS, MAY 15, 1967–AUGUST 15, 1967
H. J. Goldsmith, J. R. Moser, and T. Webb 15 Aug. 1967 35 p ref
(Contract NASw-1577)
(NASA-CR-89308) CSCL 07D

Corrosion potentials of Raney cobalt; Raney nickel; iron; Raney alloys of nickel, cobalt, and silver; carbides; and nitrocarbides were obtained to test these materials as anodic catalysts for ammonia in 30% KOH, carbon monoxide in 2N H_2SO_4, and pH-3 acetate buffer fuel-cell electrolytes. Surface areas were determined by double layer capacitance. Results indicate that none of the nickel or cobalt materials appear to be very good catalysts for ammonia oxidation, although some were three times as good as the iron catalysts. For carbon monoxide two nickel–silver materials (RAL-10 and 32NC) look promising, and three iron materials (10C, 23C, and 1NC) may be potentially good catalysts with increased surface areas. Acetate electrolyte buffered at pH-3 gives better potentials and less corrosion than 2N H_2SO_4, but at the expense of lower currents. L.S

N67-38987# Bettis Atomic Power Lab., Pittsburgh, Pa.
SLIDING-WEAR PERFORMANCE OF 135 MATERIAL COUPLES IN HIGH PURITY WATER AT 300°F AND 500°F
N. B. Dewees May 1967 83 p refs
(Contract AT(11-1)-GEN-14)
(WAPD-314) CFSTI: HC $3.00/MF $0.65

Wear performance data are presented for 135 metallic material couples (42 materials) tested in various combinations in sliding wear in a high purity water environment. The composition

of the materials tested, test procedure, and means of analyzing the data are given. The results are shown in chart form with a summary and an index. Results are evaluated according to the appearance of the worn surface, roughening tendency, wear rate, variability of wear rate with repeat testing, and consistency of wear rate under different conditions of testing. Wear performance on the rig used was compared with results from other wear test rigs. The wear evaluation for each material couple is valid for other applications having the same type of continuous motion and probably for reciprocating motion. Author (NSA)

N67-38990# Battelle Memorial Inst., Columbus, Ohio.
CORROSION OF CONSTRUCTION MATERIALS IN BOILING 13M NITRIC-0.1M HYDROFLUORIC ACIDS
Paul D. Miller, Elmer F. Stephan, Warren E. Berry, and Walter K. Boyd 30 Mar. 1967 30 p refs
(BMI-X-434) CFSTI: HC $3.00/MF $0.65

Welded and unwelded coupons of candidate constructional materials were exposed to a boiling solution (120°C) of 13M HNO_3 and 0.1M HF for times up to 240 hr. The study was made to aid ORNL in choosing a material of construction for equipment once planned for leaching waste solids from the primary reactor of the Fluidized-Bed Volatility Pilot Plant. HAPO 20(50 wt % Ni–25 wt % Cr–16 wt % Fe–6 wt % Mo–1 wt % Cu) was the most resistant of the materials studied when the durability of both welds and base metal was considered. Several other alloys showed fairly good resistance to the leach solution, but all were preferentially attacked near, or in, the welded areas; they were Corronel 230 (Ni–36 wt % Cr–5 wt % Fe–1 wt % Cu–1 wt % Mn–1 wt % Ti), Ni–50 wt % Cr, and Haynes 25 (50 wt % Co–20 wt % Cr–15 wt % W–10 wt % Ni–3 wt % Fe–1.5 wt % Mn). Author (NSA)

N67-39023# Southwest Research Inst., San Antonio, Tex. Dept. of Aerospace Propulsion Research.
FUNDAMENTAL INVESTIGATION OF LIQUID–METAL LUBRICATED JOURNAL BEARINGS Final Report
R. A. Burton and Y. C. Hsu 20 Jun. 1967 245 p refs
(Contract AT(11-1)-1228)
(RS-502; SWRI-1228P8-33) CFSTI: HC $3.00/MF $0.65

Results of an analytical and experimental research are presented on turbulent-film bearings applicable to short bearings with predominant end leakage, long tilted pads with predominant end leakage, long tilted pads with approximately tangential flow, and finite tilted pads. The problems of the turbulent squeeze film, when there is a relative velocity in the direction normal to the surface, and of the free surface with surface-tension effects are covered. Inertial effects and examples for solving the film equations are given. An annular-flow apparatus is described which is used to simulate conditions encountered by bearings in turbulent film flow. Equations are derived for thin lubricant films with end leakage and infinitely long turbulent squeeze films. Short journal bearings, bearings without end leakage, and tilted pads were analyzed. Basic equations for turbulent thin liquid films in the presence of surface tension are given. NSA

N67-39036*# Boeing Scientific Research Labs., Seattle, Wash. Solid State Physics Lab.
STRESS CORROSION CRACKING OF TITANIUM ALLOYS: ELECTROCHEMICAL MASS-TRANSPORT-KINETIC MODEL, METALLURGICAL AND MECHANICAL EFFECTS, AND PROPOSED RELATION OF ELECTROCHEMICAL, METALLURGICAL AND MECHANICAL EFFECTS Quarterly Progress Report, 1 Apr.–30 Jun. 1967
T. R. Beck and M. J. Blackburn 30 Jun. 1967 128 p refs
(Contract NAS7-489)
(NASA-CR-89315; QPR-4) CFSTI: HC $3.00/MF $0.65 CSCL 11F

A continuum electrochemical mass-transport-kinetic model was formulated and computations were made on a digital computer, giving results that appear to be consistent with velocity-current-potential data for duplex annealed Ti:8–1–1. The model predicts that the electrochemically controlled velocity is determined by mass transport of chloride, bromide, or iodide ions to the crack tip. The tip current is equivalent to formation of an adsorbed monolayer of halide ions or titanium halide. The relation of velocity to bulk halide ion concentration indicates a recycling of halide ions by displacement or hydrolysis near the tip. Ti:8–1–1 and Ti–Al alloys heat treated to a very brittle condition give stress corrosion cracking velocities greater than predicted from the electrochemical model, indicating an additional mechanical mode of fracture related to rate of change of stress intensity. The velocity in the electrochemical mode appears to be related linearly to stress intensity factor. Ti:8–1–1 heat treated to a ductile condition gives stress corrosion cracking velocities less than predicted from the electrochemical model, suggesting that ductile phases retard crack propagation. Author

N67-39222# Centro Informazioni Studi Esperienze, Milan (Italy).
DEVELOPMENT PROGRAM ON THE APPLICATION OF STEAM–WATER SPRAY TO REACTOR COOLING: INPILE CORROSION OF ZIRCALOY-2 IN STEAM–WATER MIXTURES
E. Cerrai, F. Gadda, and A. Scaroni Oct. 1966 52 p refs *Its* Topical Rept.-7
(Contract EURATOM-056.62.1-RDI)
(EURAEC-1862; EUR-3366) CFSTI: HC $3.00/MF $0.65

The effects of neutron flux on Zircaloy-2 corrosion are measured by in-pile experiments. Results of these tests are presented for given reactor conditions. Effects of temperature on corrosion rate is also shown. Local fast neutron effects are considered. Numerical examples are presented. NSA

N67-39363 Glacier Metal Co., Ltd., Wembley (England).
PLAIN BEARINGS FOR POWER TRANSMISSION MACHINERY
S. O. Rafique *In* Brit. Gear Manuf. Assoc., The Design, Manuf. and Use of Bearings in Power Transmission Machinery Nov. 1966 p 1–10 ref (See N67-39362 23-15)

Problems in designing plain bearings for power transmission machinery, are discussed. Applications in which there is interaction, are discussed; particularly with respect to marine machinery. The load carrying capacity/speed interaction in marine machinery, and the utilization of the interaction in manufacturing rolling mill machinery, is described. Also discussed are the technique of starting up electrical motors, and the coefficient of friction in gearboxes. L.S.

N67-39544# Naval Research Lab., Washington, D. C.
THE CORROSION BEHAVIOR OF STAINLESS STEELS IN SEA WATER
M. H. Peterson and T. J. Lennox, Jr. Jun. 1967 32 p refs
(NRL-MEMO-1795; AD-657938)

The corrosion behavior of several series of stainless steels is discussed. Photographs of typical attack in both experimental panels and operational equipment are shown. Because of the susceptibility of stainless steel to pitting, its use in sea water should be avoided in new designs. The 300 series, however, may be used if provided with cathodic protection. The 400 series stainless steels are unsuitable for use in sea water even if provided with cathodic protection. Author (TAB)

N67-39556# Air Force Systems Command, Wright-Patterson AFB, Ohio. Air Force Materials Lab.
AN EXPERIMENTAL APPARATUS FOR THE MEASUREMENT OF SESSILE DROP CONTACT ANGLES AT ELEVATED TEMPERATURES Technical Report, Jan.–Dec. 1966
W. L. Clow and Tung Liu Jun. 1967 20 p refs
(AFML-TR-67-152; AD-658023)

An equipment suitable for the measurement of the contact angles of molten sessile drops on solid substrate was developed. Temperatures up to 2250F may be readily controlled to within plus or minus 10F for long periods of time. The environment of the specimens may be either vacuum (to 0.00001 Torr) or a specific gas. Photographic techniques were used to record the contact angles. Experimental results of molten Na2B4O7 on metal substrates showed a standard deviation of less than 2 deg. The uncertainty introduced by the angle measurement process was shown not to exceed +2 or -2 deg. Author (TAB)

N67-39562# Army Weapons Command, Rock Island, Ill. Research and Engineering Div.
USE OF THE ELLIPSOMETER IN THE MEASUREMENT OF THIN FILMS Technical Report, Jul. 1965–Oct. 1966
Bernard J. Bornong Jul. 1967 37 p refs
(RIA-67-1859; AD-658063)

Work was performed to outline procedures for use of the ellipsometer in thin film measurement for basic studies on corrosion and corrosion inhibition. The Poincare sphere was used as a geometrical model to analyze ellipsometer readings in terms of polarization forms of light. Changes in polarization form were used to obtain thickness and refractive index of thin films of adsorbed inhibitors or corrosion products. A five-layer barium stearate film and adsorbed monolayers of stearic acid on chrome were measured. Conclusions are that procedures outlined in the report give results consistent with published results. Ellipsometry measures films with thickness of the order of molecular dimensions. Film growth in adsorption and corrosion processes can be observed beginning in their earliest stages. TAB

N67-39798* Mobil Oil Corp., Paulsboro, N. J. Research Dept.
MICROFOG LUBRICANT APPLICATION SYSTEM FOR ADVANCED TURBINE ENGINE COMPONENTS. TASK I: THEORY, EQUIPMENT, AND EXPERIMENTAL APPROACHES TO PRINCIPAL VARIABLES
. Shim and S. J. Leonardi 29 Sep. 1967 70 p refs
(Contract NAS3-9400)
(NASA-CR-72291) CSCL 11H

A test apparatus for the determination of critical properties of lubricants as microfogs is described. The test rig provides a range of conditions such as might be encountered in a "once through" lubrication system for high speed aircraft engines, and will measure the velocities and size distributions of microfog streams and the rates at which they wet a solid surface at elevated temperatures. Key considerations in designing a microfog lubricant application system are discussed from practical and theoretical points of view. Author

N67-39894# Naval Research Lab., Washington, D. C.
STRESS-CORROSION CRACKING CHARACTERISTICS OF ALLOYS OF TITANIUM IN SALT WATER
J. W. Judy, Jr. and R. J. Goode 21 Jul. 1967 53 p refs
(ARPA Order 878)
(NRL-6564; AD-658721)

The salt water stress-corrosion cracking (SCC) characteristics have been determined for a large number of titanium alloys representatives of commercial production. These data were compiled as part of an NRL program directed to determining the underlying principles of SCC in metals and to establishing procedures for improving the SCC resistance of these metals as well as learning to tolerate the problem where it exists. The SCC resistance was determined using a precracked cantilever bend specimen with analysis by fracture mechanics techniques. The test results for the spectrum of alloys and weldments studied indicate that no correlation with mechanical properties exists, which makes precise prediction of SCC properties of particular alloys difficult, if not impossible. The data obtained provide guideline information for programs similar in nature to the NRL program as well as for alloy development, design and materials selection, and specifications and quality control. Author (TAB)

N67-39928# Mechanical Technology, Inc., Lathan, N. Y.
A SEMI-IMPLICIT NUMERICAL METHOD FOR TREATING THE TIME TRANSIENT GAS LUBRICATION EQUATION
Vittorio Castelli and Charles H. Stevenson Mar. 1967 17 p refs
(Contract Nonr-3730(00))
(MTI-67TR14) CFSTI: HC$3.00/MF$0.65

A numerical method is presented for treating the time transient Reynolds equation which has the numerical stability properties of implicit schemes and the speed of execution of explicit methods. These advantages make this method quite suitable for both steady-state and transient calculations. Author (NSA)

N67-40215 Aerospace Industries Association of America, Inc., Washington, D. C. Materials and Structures Committee.
EVALUATION OF ALUMINUM ALLOY 7001-T75
August Cicinella Dec. 1966 114 p
(TR-101) Available from National Standards Assoc., Inc., Washington, D. C.: $7.50

The purpose of this work was to establish design criteria for a material with the strength of 7075-T6 and virtual immunity to stress and exfoliation corrosions. The alloy 7001-T75 was evaluated in the form of sheet, plate, extruded, hand forged, and die forged. The results of tensile tests for each 7001-T75 product form show the strength to be above the required minimums of applicable standards for 7075-T6 but in general below the typical or "B" values. In modifying artificial aging cycles to improve resistance to stress and exfoliation corrosions, strength and corrosion resistance are a trade-off. Thermal cycles that provide the greatest corrosion resistance result in the lowest strength and vice versa. One tensile test in the transverse grain direction was below the minimum for 7075-T6, the averages of all other tests were above. Alternate immersion corrosion tests showed that 7001-T75 is resistant to stress corrosion cracking and that it will pass a 30-day test. Loaded specimen sizes must be selected to prevent mechanical failure due to cross section reduction resulting from pitting corrosion. 7001-T75 is resistant to exfoliation corrosion but is not immune to intergranular attack. Fracture toughness characteristics of 7001-T75 were found to be intermediate to those for 7075-T6 and 7178-T6. K.W.

N67-40258# Franklin Inst., Philadelphia, Pa.
ANALYTICAL AND EXPERIMENTAL INVESTIGATIONS INTO THE STABILITY CHARACTERISTICS OF GAS-LUBRICATED TILTING-PAD JOURNAL HEARINGS
John T. Mc Cabe and Otto Decker Durham, N. C., Army Res. Office, Apr. 1967 37 p refs Presented at the Univ. of Southampton Gas Bearing Symp., Apr. 1967 *Its* Paper No. 17
(Contract DA-31-124-ARO(D)-147)
(AROD-4372-2; AD-657538)

The gas-lubricated tilting-pad journal bearing has been successfully developed to meet the requirements imposed by ground-based and space-power machinery. Satisfactory performance in applications such as gas circulators, Brayton cycle turbocompressors and turboalternators, and many others is a direct consequence of the well balanced analytical and experimental programs conducted both in the U.S.A. and the U.K. Experience

indicates that prediction of steady-state performance only, however accurate, is insufficient to provide adequate insight into actual machine operation or to minimise hardware development problems. Dynamic performance, in terms of the interactions between rotor, bearings, and bearing-support system, must be carefully evaluated as part of the analytical procedure and the results filtered into the final design. In addition, the influence of pibot configuration, pre-load, materials, etc., must be established and carefully incorporated into each application. Author (TAB)

N67-40352# Los Alamos Scientific Lab., N. Mex.
HIGH-TEMPERATURE ENVIRONMENTAL TESTING OF LIQUID PLUTONIUM FUELS
R. L. Andelin, L. D. Kirkbride, and R. H. Perkins 17 Jul. 1967 24 p refs
(Contract W-7405-ENG-36)
(LA-3631) CFSTI: HC $3.00/MF $0.65

Equipment for testing containers for liquid Pu alloys at 900° to 1100°C was developed and used. Uncarburized and carburized Ta and Ta–5W capsules were tested with Pu, Pu–Fe, and Pu–Co–Ce. The Pu–Co–Ce alloys were less corrosive than Pu–Fe (10 at.% Fe), which in turn was less corrosive than Pu. Carburization of Ta and Ta–5W containers greatly improved their corrosion resistance to liquid Pu alloys. Carburized Nb–10W and Nb–1Zr alloys were satisfactory containers for Pu–Co–Ce alloys containing 2 g Pu/cm^3. Author (NSA)

1966
IAA ABSTRACTS

A66-33586 #
COMPLIANCE UNDER A SMALL TORSIONAL COUPLE OF AN ELASTIC PLATE PRESSED BETWEEN TWO IDENTICAL ELASTIC SPHERES.
J. J. O'Connor (Minnesota, University, Dept. of Aeronautics and Engineering Mechanics, Minneapolis, Minn.).
ASME, Transactions, Series E - Journal of Applied Mechanics, vol. 33, June 1966, p. 377-383. 13 refs.
NSF-supported research.

The object of the analysis is to calculate the surface shear traction and the torsional compliance of an elastic system comprising a plate pressed between identical spheres. The problem is formulated in terms of an integral equation which is solved numerically. The parameters are the plate thickness and ratio of shear moduli. Solutions are obtained for all except extremely thin plates, for which a previous approximate solution is shown to be valid. The contact stress distribution is always close to the well-known distribution appropriate to the half-space, with a singularity at the edge of the contact circle, unless the plate is simultaneously thin and flexible. A thin flexible plate confines the singularity to a very small region at the edge of the contact circle, the stress elsewhere being essentially proportional to radius. The torsional compliance predicted by the analysis agrees well with experiment. (Author)

A66-33690
GLASS REINFORCED PLASTICS FOR HELICOPTER PRIMARY STRUCTURES.
J. S. Wilson (Westland Aircraft, Ltd., Fairey Aviation Div., Hayes, Middx., England).
(Symposium on the Noise and Loading Actions on Helicopters, V/STOL Aircraft and Ground Effect Machines, Institute of Sound and Vibration Research, Southampton, England, Aug. 30-Sept. 3, 1965, Paper.)
Journal of Sound and Vibration, vol. 3, May 1966, p. 510-520. 11 refs.
Research supported by the Ministry of Aviation.

Glass reinforced plastics are described from the viewpoint of a structural engineer engaged on the development of helicopter structures of superior resistance to fatigue loading, free from corrosion problems, and with consequently reduced maintenance costs. Emphasis is placed on the wide variety of glass reinforced plastic materials, the dependence of their mechanical properties upon the manufacturing technique, and on test methods. Successful primary structures can be developed with these materials provided their properties are used to advantage and their limitations are understood. (Author)

A66-34243
SUPERCONDUCTING BEARING.
B. Daniels and P. W. Matthews (British Columbia, University, Dept. of Physics, Vancouver, Canada).
Review of Scientific Instruments, vol. 37, June 1966, p. 750-753. 7 refs.
Research supported by the National Research Council.

A superconducting bearing is described which depends for its operation on the conservation of the fluxoid in a closed loop of superconductor. In operation this bearing is identical with the well-known Beams magnetic suspension, except that the function of the servomechanism is performed automatically by the superconducting loop. The observed load characteristic of the present bearing is compared with theoretical predictions, and a practical rotor is described. (Author)

A66-34383
FLEXIBLE TUBE HEAT EXCHANGERS.
R. E. Githens, W. R. Minor, and V. J. Tomsic (Du Pont de Nemours and Co., Inc., Wilmington, Del.).
(American Institute of Chemical Engineers and American Society of Mechanical Engineers, National Heat Transfer Conference, 8th, Los Angeles, Calif., Aug. 8-11, 1965, Paper; Chemical Engineering Progress, vol. 61, July 1965, p. 55-62.)
Chemical Engineering Progress, Symposium Series, no. 64, 1966, p. 191-199. 6 refs.

Study of the properties of small-tube Teflon heat exchangers. It is shown that desirable properties of high corrosion resistance, smooth slippery surface, and tube flexibility are obtained with Teflon. Moreover, heat transfer is found to be comparable to that of metal units in gas and viscous liquid services. In cases where the overall heat-transfer coefficient is less than that of metal units the disadvantage is offset by the high surface area compaction. A.B.K.

A66-34400
FRETTING AND FRETTING CORROSION.
Lubrication, vol. 52, no. 4, 1966, p. 49-64. 45 refs.

Discussion of basic fretting, defined as a form of wear resulting from oscillating or vibratory motion of limited amplitude, and of fretting corrosion, also called "friction oxidation." Fretting and fretting corrosion may lead to fatigue failures, galling, and jamming of critical clearances with abrasive debris. Aluminum and stainless steel are very susceptible to fretting corrosion. The scope of fretting, the detection of fretting corrosion, and the mechanism of fretting are considered in some detail. With reference to lubrication as a means of preventing fretting, it has been found that the feedability of a grease lubricant is of overriding importance. Effects of load, surface finish and closeness of fit, hardness and materials, fatigue, vibration amplitude or oscillation, coefficient of friction, ambient temperature, and of humidity are examined. Some experimental work is briefly described, and comments are made on methods of mitigating the problem. F.R.L.

A66-34558
A STUDY OF SYSTEM PARAMETERS AFFECTING SELF-EXCITED TORSIONAL OSCILLATIONS.
John D. Kemper (California, University, College of Engineering, Davis, Calif.).
(Society for Experimental Stress Analysis, International Congress on Experimental Mechanics, 2nd, Washington, D.C., Sept. 28-Oct. 1, 1965, Paper.)
Experimental Mechanics, vol. 6, July 1966, p. 342-349. 9 refs.

Self-excited oscillations are of considerable importance in mechanical systems, and are capable of completely defeating the purpose for which a device is intended, including the possibility of self-destruction. The results of a theoretical and experimental investigation of this phenomenon are presented, with particular reference to the effect of variations in the system parameters upon the critical threshold velocity at which such oscillations commence. Good correspondence between theory and experiment is observed. Results are presented in terms of dimensionless parameters β (dependent upon system stiffness and solid friction) and ζ (internal damping ratio). It is concluded that for $\beta < 0.0001$ (very stiff system) there is little danger of self-excited oscillations, and also that the critical threshold velocity is extremely sensitive to small changes in ζ when ζ is small (on the order of $\zeta = 0.01$). (Author)

A66-34650
LUBRICATION FOR SPACECRAFT APPLICATIONS.
W. C. Young and F. J. Clauss (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Research Laboratories, Palo Alto, Calif.).
(American Society of Lubrication Engineers, Annual Meeting, 20th, Detroit, Mich., May 3-5, 1965, Paper.)
Lubrication Engineering, vol. 22, June 1966, p. 219-223; Discussion, R. D. Brown (Southwest Research Institute, San Antonio, Tex.), p. 223-227; Authors' Closure, p. 227.

The purpose of this paper is to examine the usefulness of oils, greases, reinforced polytetrafluoroethylene, and other types of lubrication under space conditions of vacuum, temperature, and radiation. Experimental results from the use of various lubricants on instrument-size ball bearings in ultrahigh vacuum (10^{-7} to 10^{-9} torr), temperature (up to 300°F), and radiation (over 3×10^7 roentgens of gamma radiation) are reviewed. Selected oils and greases have been demonstrated to perform satisfactorily under such conditions for lifetimes of 20,000 hr, and more, and they are generally the most suitable type of lubrication for use in the space environment. (Author)

A66-34981
EFFECT OF GRAPHITE CONTENT ON THE ANTIFRICTION PROPERTIES OF METALLOGRAPHITE MATERIALS.
L. I. Pugina, I. M. Fedorchenko, and N. E. Ponomarenko (Akademiia Nauk Ukrainskoi SSR, Institut Problem Materialovedeniia, Kiev, Ukrainian SSR).
(Poroshkovaia Metallurgiia, vol. 5, Sept. 1965, p. 53-58.)
Soviet Powder Metallurgy and Metal Ceramics, Sept. 1965, p. 737-740. 6 refs. Translation.

A66-35010
ON THE QUANTITATIVE EVALUATION OF THE CORROSION FATIGUE OF METALS.
V. V. Romanov (Akademiia Nauk SSSR, Institut Metallurgii, Moscow, USSR).
(Zashchita Metallov, vol. 1, July-Aug. 1965, p. 391-395.)
Protection of Metals, vol. 1, July-Aug. 1965, p. 345-348. Translation.

A66-35011
CERTAIN PROBLEMS IN ESTIMATING CONTACT CORROSION OF PLANE AND CYLINDRICAL METAL SURFACES.
Iu. Ia. Iossel', E. S. Kochanov, and M. G. Strunskii (Tsentral'nyi Nauchno-Issledovatel'skii Institut, Leningrad, USSR).
(Zashchita Metallov, vol. 1, July-Aug. 1965, p. 410-419.)
Protection of Metals, vol. 1, July-Aug. 1965, p. 361-369. 7 refs. Translation.

A66-35462
EFFECTS OF TEMPERATURE ON THE COEFFICIENT OF DRY FRICTION OF TITANIUM AND ALLOYS VK6, T15K6, AND VT15 ON TITANIUM.
A. M. Zuev (Kurganskii Mashinostroitel'nyi Institut, Kurgan, USSR).
(Fizika, vol. 8, no. 2, 1965, p. 156-158.)
Soviet Physics Journal, Mar.-Apr. 1965, p. 103, 104. 7 refs. Translation.

Experimental investigation of the coefficient of dynamic friction for titanium type VT1 on titanium and the alloys VK6, T15K6, and VT15. The coefficient of dry friction against titanium is shown as a function of temperature. The coefficient is virtually constant up to 400°C, being 0.34 for Ti-Ti and not over 0.28 for other pairs. There is a slow rise above 400°C. Some of the runs extended up to 800°C, but the values found at 750 and 800°C were almost the same as those at 700°C, which indicates that the coefficient of friction is probably maximal around 700°C for VK6, T15K6, and VT15 on Ti. M.M.

A66-35524 #
SPECTROMETRIC ANALYSIS TO DETERMINE WEAR METAL IN ENGINE LUBRICATING OIL.
Donald C. Kittinger and Allan Bond (Royal Air Force, Farnborough, Hants., England).
IN: NAECON/66; PROCEEDINGS OF THE ANNUAL NATIONAL AEROSPACE ELECTRONICS CONFERENCE, 18TH, DAYTON, OHIO, MAY 16-18, 1966. TECHNICAL PAPERS. [A66-35501 19-21]
Conference sponsored by the Dayton Section of the Institute of Electrical and Electronics Engineers.
Dayton, Ohio, Institute of Electrical and Electronics Engineers, 1966, p. 251-256.

Description of spectrometric analysis of a lubricant to obtain early indication of an imminent failure production cycle. The theory of the technique is reviewed and the early practical applications of spectrometry to the analysis of lubricants are studied. A system engineering group program, Task 314705, with its early objectives, its phases, and its mechanics, is reviewed. The final review of the results leads to the conclusion that spectrometric oil analysis is a valid procedure for the assessment of failure probability of turbojet-engine oil-wetted parts. M.F.

A66-35647
STRESS-CORROSION CRACKING OF TITANIUM; AMERICAN SOCIETY FOR TESTING AND MATERIALS, NATIONAL MEETING, 5TH, SEATTLE, WASH., OCTOBER 31-NOVEMBER 5, 1965, PAPERS.
Symposium sponsored by the American Society for Testing and Materials, and the American Society of Mechanical Engineers, Joint Committee on Effect of Temperature on the Properties of Metals.
Philadelphia, American Society for Testing and Materials (ASTM Special Technical Publication no. 397), 1966. 259 p.
Members, $9.80; nonmembers, $14.

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THE RELATIVE STRESS-CORROSION SUSCEPTIBILITY OF TITANIUM ALLOYS IN THE PRESENCE OF HOT SALT. D. E. Piper and D. N. Fager (Boeing Co., Seattle, Wash.), p. 31-52. 8 refs. [See A66-35649 19-17]
ENVIRONMENTAL EFFECTS STUDIES ON SELECTED TITANIUM ALLOYS. R. F. Simenz, J. M. Van Orden, and G. G. Wald (Lockheed Aircraft Corp., Burbank, Calif.), p. 53-79. 6 refs. [See A66-35650 19-17]
THE MECHANISM OF SALT ATTACK ON TITANIUM ALLOYS. V. C. Petersen (Crucible Steel Company of America, Pittsburgh, Pa.) and H. B. Bomberger (Reactive Metals, Inc., Niles, Ohio), p. 80-94. 9 refs. [See A66-35651 19-17]
INVESTIGATION OF LONG-TERM EXPOSURE EFFECTS UNDER STRESS OF TWO TITANIUM STRUCTURAL ALLOYS. George Martin (North American Aviation, Inc., Los Angeles, Calif.), p. 95-121. [See A66-35652 19-17]
EFFECTS OF ENVIRONMENT ON CRACKING IN TITANIUM ALLOYS. A. J. Hatch, H. W. Rosenberg (Titanium Metals Corporation of America, Henderson, Nev.), and E. F. Erbin (Titanium Metals Corporation of America, West Caldwell, N.J.), p. 122-136. 12 refs. [See A66-35653 19-17]
BASIC MECHANISMS OF STRESS-CORROSION CRACKING OF TITANIUM. S. P. Rideout, M. R. Louthan, Jr., and C. L. Selby (Du Pont de Nemours and Co., Aiken, S.C.), p. 137-151. 12 refs. [See A66-35654 19-17]
AN INVESTIGATION OF STRESS-CORROSION FAILURES IN TITANIUM COMPRESSOR COMPONENTS. R. E. Duttweiler, R. R. Wagner, and K. C. Antony (General Electric Co., Cincinnati, Ohio), p. 152-178. 7 refs. [See A66-35655 19-32]
EFFECTS OF SALT ATMOSPHERE ON CRACK SENSITIVITY OF COMMERCIAL TITANIUM ALLOYS AT 600 TO 900 F. M. J. Donachie, Jr., W. P. Danesi, and A. A. Pinkowish (United Aircraft Corp., East Hartford, Conn.), p. 179-193. 24 refs. [See A66-35656 19-17]

SALT STRESS CORROSION OF Ti-8Al-1Mo-1V ALLOY SHEET AT ELEVATED TEMPERATURES. G. J. Heimerl, D. N. Braski, D. M. Royster, and H. B. Dexter (NASA, Hampton, Va.), p. 194-214. 11 refs. [See A66-35657 19-17]

CHEMICAL AND PHYSICAL MECHANISMS OF SALT STRESS-CORROSION CRACKING IN THE TITANIUM 8-1-1 ALLOY. H. L. Logan, M. J. McBee, C. J. Bechtoldt, B. T. Sanderson, and G. M. Ugiansky (National Bureau of Standards, Washington, D.C.), p. 215-229. 8 refs. [See A66-35658 19-17]

THE DIFFUSION OF CORROSION PRODUCTS IN HOT-SALT STRESS-CORROSION CRACKING OF TITANIUM. R. L. Kirchner (Black and Decker Manufacturing Co., Towson, Md.) and E. J. Ripling (Materials Research Laboratory, Inc., Richton Park, Ill.), p. 230-245. 6 refs. [See A66-35659 19-17]

SEA-WATER EMBRITTLEMENT OF TITANIUM. I. R. Lane, Jr., J. R. Cavallaro, and A. G. S. Morton (U.S. Navy, Annapolis, Md.), p. 246-259. 5 refs. [See A66-35660 19-17]

A66-35648

ELEVATED-TEMPERATURE STATIC AND DYNAMIC SEA-SALT STRESS CRACKING OF TITANIUM ALLOYS.

R. V. Turley and C. H. Avery (Douglas Aircraft Co., Inc., Aircraft Group, Long Beach, Calif.).

IN: STRESS-CORROSION CRACKING OF TITANIUM; AMERICAN SOCIETY FOR TESTING AND MATERIALS, NATIONAL MEETING, 5TH, SEATTLE, WASH., OCTOBER 31-NOVEMBER 5, 1965, PAPERS. [A66-35647 19-17]
Symposium sponsored by the American Society for Testing and Materials, and the American Society of Mechanical Engineers, Joint Committee on Effect of Temperature on the Properties of Metals.
Philadelphia, American Society for Testing and Materials (ASTM Special Technical Publication no. 397), 1966, p. 1-30. 7 refs.
Research supported by the Douglas Independent Research and Development Program; Contract No. AF 33(657)-8543.

Titanium alloys 6Al-4V, 8Al-1Mo-1V, 4Al-3Mo-1V, 5Al-2.5Sn, and RS-140 were evaluated for susceptibility to elevated-temperature static and dynamic sea-salt stress cracking to determine the most promising alloys for application to advanced aircraft. The nature of this cracking was also studied for evidence that would reveal the fundamental mechanisms involved. All alloys were susceptible to stress-corrosion cracking, and the susceptibility was increased with elevated temperature. Alloy 4Al-3Mo-1V was the most resistant, and 5Al-2.5Sn was least resistant. Alloy 8Al-1Mo-1V was the only one susceptible to corrosion fatigue. Fatigue precracks, anodizing, thickness, and grain direction had little or no effect on stress-corrosion susceptibility. Welding and stress relieving increased the stress-corrosion susceptibility. Cracks initiated and propagated from corrosion grooving at grain boundaries and transgranular crystallographic planes without relating to pitting, roughness, or other surface irregularities. Extended research to reveal mechanisms operative during stress corrosion of titanium is recommended as a means of understanding the factors which reduce or increase resistance to stress-corrosion cracking. (Author)

A66-35649

THE RELATIVE STRESS-CORROSION SUSCEPTIBILITY OF TITANIUM ALLOYS IN THE PRESENCE OF HOT SALT.

D. E. Piper and D. N. Fager (Boeing Co., Materials Technology Unit, Seattle, Wash.).

IN: STRESS-CORROSION CRACKING OF TITANIUM; AMERICAN SOCIETY FOR TESTING AND MATERIALS, NATIONAL MEETING, 5TH, SEATTLE, WASH., OCTOBER 31-NOVEMBER 5, 1965, PAPERS. [A66-35647 19-17]
Symposium sponsored by the American Society for Testing and Materials, and the American Society of Mechanical Engineers, Joint Committee on Effect of Temperature on the Properties of Metals.
Philadelphia, American Society for Testing and Materials (ASTM Special Technical Publication no. 397), 1966, p. 31-52. 8 refs.

Steady-state stress-corrosion tests at elevated temperature were performed on three titanium alloys. Mill annealed titanium 6Al-4V was the least susceptible, followed in order of increasing susceptibility by titanium 8Al-1Mo-1V and titanium 6Al-6V-2Sn. Sodium chloride was more detrimental than ASTM synthetic salt. Extensive tests were conducted on duplex annealed titanium 8Al-1Mo-1V. Cyclic state testing of this alloy indicated an absence of stress-corrosion cracking and demonstrated that the time at temperature below the maximum operating temperature of a supersonic aircraft might be an important variable. Exposure tests on brake-formed, stress-relieved titanium 8Al-1Mo-1V sheet specimens indicated a deteriorating effect distinct from stress-corrosion cracking. Fatigue crack growth and fracture toughness determinations indicated no embrittling effects in titanium 8Al-1Mo-1V exposed to hot salt in the absence of stress. (Author)

A66-35650

ENVIRONMENTAL EFFECTS STUDIES ON SELECTED TITANIUM ALLOYS.

R. F. Simenz, J. M. Van Orden, and G. G. Wald (Lockheed Aircraft Corp., Lockheed-California Co., Burbank, Calif.).

IN: STRESS-CORROSION CRACKING OF TITANIUM; AMERICAN SOCIETY FOR TESTING AND MATERIALS, NATIONAL MEETING, 5TH, SEATTLE, WASH., OCTOBER 31-NOVEMBER 5, 1965, PAPERS. [A66-35647 19-17]
Symposium sponsored by the American Society for Testing and Materials, and the American Society of Mechanical Engineers, Joint Committee on Effect of Temperature on the Properties of Metals.
Philadelphia, American Society for Testing and Materials (ASTM Special Technical Publication no. 397), 1966, p. 53-78; Discussion, M. Ensanian (Bell Aerospace Corp., Bell Aerosystems Co., Buffalo, N.Y.), p. 79. 6 refs.

The elevated temperature stress-corrosion cracking behavior of several titanium alloys was investigated. The results indicate varying degrees of susceptibility, depending on alloy, test conditions, heat treatment, and so on. The need for additional work and refinement and standardization of test conditions is evident from the variations in test results reported here and by other researchers. Materials tested included sheet alloys Ti-8Al-1Mo-1V, Ti-6Al-4V, Ti-5Al-2.5Sn, Ti-13V-11Cr-3Al, Ti-4Al-3Mo-1V, and extrusion alloys Ti-8Al-1Mo-1V, Ti-6Al-6V-2Sn, Ti-6Al-4V, and Ti-7Al-4Mo. Test exposure temperatures from 500 to 650°F were used. Other test variables were salt type and thickness, heat treatment strength level, stress level, fabrication effects (spotwelding, fusion welding, bend forming, and so on) and exposure time. It has not been established whether laboratory stress-corrosion behavior in titanium alloys can be a problem in actual service; however, the approach at Lockheed will be to select and control materials for use in SST construction which are shown to be unaffected in laboratory elevated temperature stress-corrosion testing. (Author)

A66-35651

THE MECHANISM OF SALT ATTACK ON TITANIUM ALLOYS.

V. C. Petersen (Crucible Steel Company of America, Pittsburgh, Pa.) and H. B. Bomberger (Reactive Metals, Inc., Niles, Ohio).

IN: STRESS-CORROSION CRACKING OF TITANIUM; AMERICAN SOCIETY FOR TESTING AND MATERIALS, NATIONAL MEETING, 5TH, SEATTLE, WASH., OCTOBER 31-NOVEMBER 5, 1965, PAPERS. [A66-35647 19-17]
Symposium sponsored by the American Society for Testing and Materials, and the American Society of Mechanical Engineers, Joint Committee on Effect of Temperature on the Properties of Metals.
Philadelphia, American Society for Testing and Materials (ASTM Special Technical Publication no. 397), 1966, p. 80-94. 9 refs.
Contract No. NOas-60-6004-c(1).

Stress corrosion in titanium is caused by complex oxidation reactions. Reaction products were identified by X-ray diffraction, mass spectrometry, and gas chromatography. Chlorine gas was identified as an intermediate and regenerable reaction product that has a strong tendency to crack titanium. No reaction occurs if oxygen or oxide is absent. Extensive damage can occur even if only a small amount of salt is present. This sensitivity is attributed to recycling of chlorine. Of several surface treatments tested, metal coatings are most promising. Electrolytic nickel coatings, dipped aluminum coatings, and zinc coatings were most effective. (Author)

A66-35652
INVESTIGATION OF LONG-TERM EXPOSURE EFFECTS UNDER STRESS OF TWO TITANIUM STRUCTURAL ALLOYS.
George Martin (North American Aviation, Inc., Los Angeles Div., Los Angeles, Calif.).
IN: STRESS-CORROSION CRACKING OF TITANIUM; AMERICAN SOCIETY FOR TESTING AND MATERIALS, NATIONAL MEETING, 5TH, SEATTLE, WASH., OCTOBER 31-NOVEMBER 5, 1965, PAPERS. [A66-35647 19-17]
Symposium sponsored by the American Society for Testing and Materials, and the American Society of Mechanical Engineers, Joint Committee on Effect of Temperature on the Properties of Metals.
Philadelphia, American Society for Testing and Materials (ASTM Special Technical Publication no. 397), 1966, p. 95-120; Discussion, F. A. Crossley (Illinois Institute of Technology, Research Institute, Chicago, Ill.) and M. Ensanian (Bell Aerospace Corp., Bell Aerosystems Co., Buffalo, N.Y.), p. 120, 121.

Notched and unnotched sheet specimens of two titanium alloys, Ti-6Al-4V and Ti-8Al-1Mo-1V, were exposed at 650°F and stressed by a cantilever arrangement to 25 to 30% of their yield stress. Specimens were tested for periods up to 20,000 hr as received, coated with salt, coated with a silver brazing alloy, and coated with a silver brazing alloy and salt. A fifth set was prepared like the last but was exposed cyclically to furnace atmosphere for two-week periods and then in a humidity cabinet at 100°F for two weeks. Specimens were studied by optical microscopy, electron microscopy, and X-ray diffraction. Electron microscopy indicates that cracking is primarily intergranular, but transgranular cracks are possible. X-ray diffraction studies show that titanium chloride and sodium titanate are absent from the corrosion products. Silver braze coatings cause rapid surface demonstration. There is a complete loss of adhesion between braze and parent material after a few thousand hours exposure. (Author)

A66-35653
EFFECTS OF ENVIRONMENT ON CRACKING IN TITANIUM ALLOYS.
A. J. Hatch (Titanium Metals Corporation of America, Henderson, Nev.), H. W. Rosenberg (Titanium Metals Corporation of America, Metallurgical Research Div., Henderson, Nev.), and E. F. Erbin (Titanium Metals Corporation of America, Applications Development Center, West Caldwell N.J.).
IN: STRESS-CORROSION CRACKING OF TITANIUM; AMERICAN SOCIETY FOR TESTING AND MATERIALS, NATIONAL MEETING, 5TH, SEATTLE, WASH., OCTOBER 31-NOVEMBER 5, 1965, PAPERS. [A66-35647 19-17]
Symposium sponsored by the American Society for Testing and Materials and the American Society of Mechanical Engineers, Joint Committee on Effect of Temperature on the Properties of Metals.
Philadelphia, American Society for Testing and Materials (ASTM Special Technical Publication no. 397), 1966, p. 122-136. 12 refs.

The laboratory conditions under which hot-salt cracking can occur in titanium alloys are reviewed and orders of merit among the alloys established. The large differences among alloys give promise of new alloys immune to the phenomenon. Hot-salt cracking is a case of classical stress corrosion. Alloy research and development disclose a system of titanium alloys that is immune to hot-salt cracking. One promising composition, Ti-2Al-4Zr-4Mo, is shown to have excellent combinations of mechanical properties. The fracture toughness of commercial titanium alloys in salt water is also examined. In the presence of fatigue cracks actively extending under applied loads, salt water can have the effect of reducing the crack propagation resistance of several titanium alloys. Because salt water has no effects on titanium alloys in the absence of cracks, its environmental effect is not classical stress corrosion. The problem can be largely eliminated in Ti-8Al-1Mo-1V sheet by creating microstructures consisting of a continuous matrix of transformed beta. (Author)

A66-35654
BASIC MECHANISMS OF STRESS-CORROSION CRACKING OF TITANIUM.
S. P. Rideout (Du Pont de Nemours and Co., Nuclear Materials Div., Aiken, S.C.), M. R. Louthan, Jr., and C. L. Selby (Du Pont de Nemours and Co., Savannah River Laboratory, Aiken, S.C.).
IN: STRESS-CORROSION CRACKING OF TITANIUM; AMERICAN SOCIETY FOR TESTING AND MATERIALS, NATIONAL MEETING, 5TH, SEATTLE, WASH., OCTOBER 31-NOVEMBER 5, 1965, PAPERS. [A66-35647 19-17]
Symposium sponsored by the American Society for Testing and Materials, and the American Society of Mechanical Engineers, Joint Committee on Effect of Temperature on the Properties of Metals.
Philadelphia, American Society for Testing and Materials (ASTM Special Technical Publication no. 397), 1966, p. 137-151. 12 refs. NASA-supported research.

Prepolished strips of Ti-8Al-1Mo-1V, stressed to the yield point at 650°F, cracked when exposed to either chloride, iodide, or bromide salts. Cracking was most severe in specimens exposed to pure sodium chloride (NaCl). Chemical analyses of corrosion products formed by NaCl exposures showed that aluminum was preferentially attacked. Autoradiographic techniques with radiotracers H^3, Cl^{36}, and Na^{22} were used to study the distribution of those elements in salt-coated specimens, and the results suggested that hydrochloric acid (HCl) and sodium hydroxide (NaOH) were produced by salt-metal-water reactions. Specimens exposed to HCl gas alone cracked within short times, but no cracking was produced by NaOH exposures. Experimental results can be interpreted to support the hypothesis that hot-salt cracking occurs by hydrogen embrittlement. (Author)

A66-35655
AN INVESTIGATION OF STRESS-CORROSION FAILURES IN TITANIUM COMPRESSOR COMPONENTS.
R. E. Duttweiler, R. R. Wagner, and K. C. Antony (General Electric Co., Flight Propulsion Div., Advanced Engine and Technology Dept., Cincinnati, Ohio).
IN: STRESS-CORROSION CRACKING OF TITANIUM; AMERICAN SOCIETY FOR TESTING AND MATERIALS, NATIONAL MEETING, 5TH, SEATTLE, WASH., OCTOBER 31-NOVEMBER 5, 1965, PAPERS. [A66-35647 19-17]
Symposium sponsored by the American Society for Testing and Materials, and the American Society of Mechanical Engineers, Joint Committee on Effect of Temperature on the Properties of Metals.
Philadelphia, American Society for Testing and Materials (ASTM Special Technical Publication no. 397), 1966, p. 152-178. 7 refs.

Demonstration that the cracking of J93 jet engine components manufactured from Ti-7Al-4Mo and Ti-5Al-2.5Sn results from silver chloride stress corrosion. Laboratory tests were made to demonstrate the effect of intimate contact between titanium alloys and silver and silver chloride. An investigation of the mechanism of attack suggested that the deleterious effects noted were the results of the unique ability of silver to react with, and thereby concentrate, minute amounts of chlorine such as might prevail in a test environment. Because of this behavior, silver plate was removed from all areas in the J93 engine where it came in intimate contact with titanium components. F. R. L.

A66-35657
SALT STRESS-CORROSION OF Ti-8Al-1Mo-1V ALLOY SHEET AT ELEVATED TEMPERATURES.
G. J. Heimerl (NASA, Langley Research Center, Structures Research Div., Structural Materials Branch, Hampton, Va.), D. N. Braski, D. M. Royster, and H. B. Dexter (NASA, Langley Research Center, Hampton, Va.).
IN: STRESS-CORROSION CRACKING OF TITANIUM; AMERICAN SOCIETY FOR TESTING AND MATERIALS, NATIONAL MEETING, 5TH, SEATTLE, WASH., OCTOBER 31-NOVEMBER 5, 1965, PAPERS. [A66-35647 19-17]
Symposium sponsored by the American Society for Testing and Materials, and the American Society of Mechanical Engineers, Joint Committee on Effect of Temperature on the Properties of Metals.
Philadelphia, American Society for Testing and Materials (ASTM Special Technical Publication no. 397), 1966, p. 194-214. 11 refs.

Many small self-stressed and residual-stress specimens were oated with salt, exposed up to 6400 hr at 400 to 600°F, and tested n compression and bending at room temperature to determine the tress corrosion cracking. Of the various salts, sodium chloride NaCl) was the most corrosive, and thin coatings were more damaging han thick. A decrease in oxygen and air pressure reduced stress orrosion, but the role of moisture and air velocity is still in doubt. hort thermal cycles of 2 or 4 hr from room temperature to 550°F roduced less corrosion. Titanium dichloride ($TiCl_2$) was identified s a corrosion product, but the corrosion mechanism is unknown. urface treatments, such as shot peening, nickel plating, vibratory leaning, and polyimide coatings, prevented corrosion up to 2000 hr t 600°F. (Author)

\66-35658

:HEMICAL AND PHYSICAL MECHANISMS OF SALT STRESS-:ORROSION CRACKING IN THE TITANIUM 8-1-1 ALLOY.

[. L. Logan, M. J. McBee, C. J. Bechtoldt, B. T. Sanderson, nd G. M. Ugiansky (National Bureau of Standards, Metallurgy liv., Corrosion Section, Washington, D. C.).

N: STRESS-CORROSION CRACKING OF TITANIUM; AMERICAN OCIETY FOR TESTING AND MATERIALS, NATIONAL MEETING, TH, SEATTLE, WASH., OCTOBER 31-NOVEMBER 5, 1965, 'APERS. [A66-35647 19-17]

ymposium sponsored by the American Society for Testing and laterials, and the American Society of Mechanical Engineers, oint Committee on Effect of Temperature on the Properties of letals.

hiladelphia, American Society for Testing and Materials (ASTM pecial Technical Publication no. 397), 1966, p. 215-228; Discussion [. Ensanian (Bell Aerospace Corp., Bell Aerosystems Co., uffalo, N. Y.), p. 229. 8 refs.

Stress-corrosion tests were performed on hollow cylinders nd sheet-metal specimens of Ti-8Al-1Mo-1V in contact with solid odium chloride or synthetic sea-water salt. Specimens were eated to 750°F and subjected to a 73,500 psi tensile stress. pecimens failed in times as short as 18 hr. The hollow specimens ere evaluated and then filled with oxygen or argon. No cracking ccurred unless oxygen or water vapor was present. Cracking was lso introduced in specimens preoxidized for about 65 hr and coated ith sodium chloride in an inert atmosphere under the same condi-on of temperature and stress. The authors propose that chlorine ffuses down through a stress, and probably an oxygen concentra-on gradient reacts with the metal to destroy atomic bonds and oduce stress corrosion. Specific reactions, however, have not t been determined. X-ray diffraction studies of corrosion products dicate that the usual oxides of titanium are present along with an identified phase that may be formed by reaction between sodium loride, oxygen, and the alloy. (Author)

66-35659

HE DIFFUSION OF CORROSION PRODUCTS IN HOT-SALT TRESS-CORROSION CRACKING OF TITANIUM.

. L. Kirchner (Black and Decker Manufacturing Co., Towson, d.) and E. J. Ripling (Materials Research Laboratory, Inc., ichton Park, Ill.).

I: STRESS-CORROSION CRACKING OF TITANIUM; AMERICAN OCIETY FOR TESTING AND MATERIALS, NATIONAL MEETING, TH, SEATTLE, WASH., OCTOBER 31-NOVEMBER 5, 1965, APERS. [A66-35647 19-17]

mposium sponsored by the American Society for Testing and aterials, and the American Society of Mechanical Engineers, oint Committee on Effect of Temperature on the Properties of etals.

hiladelphia, American Society for Testing and Materials (ASTM pecial Technical Publication no. 397), 1966, p. 230-245. 6 refs. ASA-sponsored research.

Description of an experimental technique for separating the aseous, liquid, and solid reaction products generated by the hot-alt corrosion of titanium. In order to separate the gaseous corro-ion products from liquids and solids, advantage was taken of the ct that the gases will diffuse across an air gap, while liquids and olids will not. To use this behavior difference, a testing technique as developed in which the corrosion products were produced on an nstressed portion of a test specimen which was separated from the stressed region in part by an air gap and, in another part, by a metal bridge. The specimen was a typical sheet tension specimen with side hooks added to its two edges. When such a specimen is loaded in tension, the hooks remain stress free. It is shown that the product that causes cracking is not a gas, and hence would not be expected to be washed away in service by a fast moving air stream. F. R. L.

A66-35660

SEA-WATER EMBRITTLEMENT OF TITANIUM.

I. R. Lane, Jr., J. R. Cavallaro, and A. G. S. Morton (U.S. Navy, Marine Engineering Laboratory, Naval Alloys Div., Annapolis, Md.).

IN: STRESS-CORROSION CRACKING OF TITANIUM; AMERICAN SOCIETY FOR TESTING AND MATERIALS, NATIONAL MEETING, 5TH, SEATTLE, WASH., OCTOBER 31-NOVEMBER 5, 1965, PAPERS. [A66-35647 19-17]

Symposium sponsored by the American Society for Testing and Materials, and the American Society of Mechanical Engineers, Joint Committee on Effect of Temperature on the Properties of Metals.

Philadelphia, American Society for Testing and Materials (ASTM Special Technical Publication no. 397), 1966, p. 246-258; Discussion, M. Ensanian (Bell Aerospace Corp., Bell Aerosystems Co., Buffalo, N. Y.), p. 258, 259. 5 refs.

Tests on titanium alloy cantilever beam specimens indicate that sea water embrittlement behavior is related to aluminum content, aging in the range 900 to 1300°F, presence of isomorphous beta stabilizers (molybdenum, vanadium, columbiun), and rate of cooling from annealing temperatures. The authors believe that during thermal cycling, regions of coherent Ti_3Al are nucleated in equilibrium with an alpha matrix. Composition and time at temperature influence this embrittling process. To reduce embrittlement, (1) lower aluminum content, (2) add elements (molybdenum or vanadium) that suppress the formation of coherent Ti_3Al, and (3) avoid or minimize thermal cycling in the critical range. Test results indicate that sea water embrittlement is an environmental-dependent brittleness triggered by an aqueous corrodent. (Author)

A66-35833 #

SOME EXPERIMENTS ON DRY LUBRICATION.

Kâşif Onaran (Istanbul, Technical University, Engineering Materials Dept., Istanbul, Turkey).

Istanbul Teknik Üniversitesi Bülteni, vol. 18, no. 2, 1966, p. 34-42. 11 refs.

Discussion of lubrication requirements for operation of equipment in a space environment. Lubricants and self-lubricating materials operating under these conditions must provide long term lubrication to obtain high reliability. Some dry lubricants have been used satisfactorily, but the service of these materials is quite limited. An attempt was made to study the possibility of transferring dry lubricant particles on to the contact surfaces during service by using separate rubbing elements made of special lubricant material. F. R. L.

A66-36135

THE ROLE OF OXYGEN IN ATTACK OF REFRACTORY METALS BY ALKALI METALS.

N. J. Hoffman and W. T. Chandler (North American Aviation, Inc., Rocketdyne Div., Canoga Park, Calif.).

IN: REFRACTORY METALS AND ALLOYS III: APPLIED ASPECTS; PROCEEDINGS OF THE THIRD TECHNICAL CONFERENCE, LOS ANGELES, CALIF., DECEMBER 9, 10, 1963. VOLUME 30. [A66-36104 19-15]

Conference sponsored by the Refractory Metals Committee, the Institute of Metals Division of the Metallurgical Society, and the Southern California Section of the American Institute of Mining, Metallurgical, and Petroleum Engineers.

Edited by R. I. Jaffee.

New York, Gordon and Breach Science Publishers, Inc., 1966, p. 509-519.

Contract No. AF 33(616)-8435.

Postulation of several roles for oxygen in promoting attack of refractory metal by alkali metals. Although most of these are but variations of oxidation/reduction reactions and polyoxide formation, enough distinct differences exist between the roles to justify attempts to establish which mechanism is occurring. At present, the problems are solved by extremely strict oxygen purity requirements. M. M.

A66-36136
CORROSION BEHAVIOR OF REFRACTORY METALS IN LIQUID LITHIUM AND CESIUM VAPORS.
J. A. De Mastry (Battelle Memorial Institute, Columbus, Ohio).
IN: REFRACTORY METALS AND ALLOYS III: APPLIED ASPECTS; PROCEEDINGS OF THE THIRD TECHNICAL CONFERENCE, LOS ANGELES, CALIF., DECEMBER 9, 10, 1963. VOLUME 30. [A66-36104 19-15]
Conference sponsored by the Refractory Metals Committee, the Institute of Metals Division of the Metallurgical Society, and the Southern California Section of the American Institute of Mining, Metallurgical, and Petroleum Engineers.
Edited by R. I. Jaffee.
New York, Gordon and Breach Science Publishers, Inc., 1966, p. 521-533.
USAF-sponsored research.

Eight refractory metals and alloys have been selected for corrosion studies in lithium at 2500°F and cesium at 2500 to 3400°F. A number of specimens have been exposed to lithium at 2500°F and cesium at 2500, 2800, and 3100°F for 100 hr. Preliminary results indicate that tungsten, W-25Re and TZM are compatible with lithium at 2500°F and with cesium at 2500, 2800, and 3100°F. The results for the W-0.9Cb alloy are inconclusive. The Ta-12W alloy shows a reaction zone with lithium and cesium at the temperatures of interest. No observations have been made on the W-15Mo, B-66, and T111 alloys. (Author)

A66-36137
A LIMITED REVIEW OF REFRACTORY ALLOY CORROSION TESTS IN POTASSIUM.
R. G. Carlson, W. F. Zimmerman, and R. G. Frank (General Electric Co., Evendale, Ohio).
IN: REFRACTORY METALS AND ALLOYS III: APPLIED ASPECTS; PROCEEDINGS OF THE THIRD TECHNICAL CONFERENCE, LOS ANGELES, CALIF., DECEMBER 9, 10, 1963. VOLUME 30. [A66-36104 19-15]
Conference sponsored by the Refractory Metals Committee, the Institute of Metals Division of the Metallurgical Society, and the Southern California Section of the American Institute of Mining, Metallurgical, and Petroleum Engineers.
Edited by R. I. Jaffee.
New York, Gordon and Breach Science Publishers, Inc., 1966, p. 535-545.
Research supported by the General Electric Independent Research and Development Program; Contracts No. AF 33(657)-7063; No. AF 33(600)-41577; No. NAS 3-2140.

Description of corrosion tests and of observations of the behavior of columbium alloy components in potassium for long periods of time at 2000 to 2200°F. The more significant test results are briefly summarized. The results obtained from isothermal capsule tests are: (1) in general, the alloys tested do not exhibit any significant corrosive attack; (2) the hardness and strength of the material exposed to the potassium vapor are higher generally than those determined for similar material exposed to potassium liquid; (3) after long-time, 2000°F exposures, there is a consistent trend of strength and hardness reductions which is probably related to morphological changes induced by aging reactions; and (4) after a 1000-hr exposure to potassium at 2000°F, AS-30, TZM, Cb-752 and Cb-1Zr alloys showed no trend toward embrittlement. M. M.

A66-36138
SOME OBSERVATIONS OF SHORT-TIME CORROSION OF REFRACTORY METALS IN LITHIUM BETWEEN 2000° AND 3000° F.
H. Hahn and M. Jaworsky (Curtiss-Wright Corp., Wood-Ridge, N. J.).
IN: REFRACTORY METALS AND ALLOYS III: APPLIED ASPECTS; PROCEEDINGS OF THE THIRD TECHNICAL CONFERENCE, LOS ANGELES, CALIF., DECEMBER 9, 10, 1963. VOLUME 30. [A66-36104 19-15]
Conference sponsored by the Refractory Metals Committee, the Institute of Metals Division of the Metallurgical Society, and the Southern California Section of the American Institute of Mining, Metallurgical, and Petroleum Engineers.
Edited by R. I. Jaffee.
New York, Gordon and Breach Science Publishers, Inc., 1966, p. 547-560. 9 refs.
Navy-supported research.

Description of the corrosion properties of various refractory metals in molten lithium, on the basis of capsule tests. The results of tests at elevated temperatures for 1-min and 4-min exposure are tabulated and illustrated graphically in terms of penetration depth, scale thickness, and weight change per unit surface area. These parameters are plotted as functions of temperature for each material. The behavior of individual materials is summarized on the basis of metallographic studies and of direct measurements of weight changes. M. M.

A66-36744
ON THE FUEL-OPTIMAL SINGULAR CONTROL OF A SYSTEM HAVING QUADRATIC AND LINEAR FRICTION.
B. F. Womack and D. G. Mackey (Texas, University, Austin, Tex.
IEEE Transactions on Automatic Control, vol. AC-11, Apr. 1966, p. 307, 308.

Demonstration of the necessary conditions for the singular time-weighted fuel-optimal control of the nonlinear system $\dot{x}_1(t) = x_2(t)$, $\dot{x}_2(t) = ax_2(t)|x_2(t)| - bx_2(t) + u(t)$ where a and b are positive constants. The control u(t) has the magnitude constraint $|u(t)| \leq 1$. B. B.

A66-37091
NEW WELDABLE HIGH-STRENGTH ALUMINUM ALLOYS FOR CRYOGENIC SERVICE.
H. Y. Hunsicker (Aluminum Company of America, Alcoa Research Laboratories, New Kensington, Pa.) and J. H. Hess (NASA, Marshall Space Flight Center, Huntsville, Ala.).
IN: ADVANCES IN CRYOGENIC ENGINEERING. VOLUME 11. PROCEEDINGS OF THE CRYOGENIC ENGINEERING CONFERENCE, WILLIAM MARSH RICE UNIVERSITY, HOUSTON, TEX., AUGUST 23-25, 1965. [A66-37059 20-23]
Edited by K. D. Timmerhaus.
New York, Consultants Bureau, Division of Plenum Press, 1966, p. 423-435; Discussion, R. B. Lee (Honeywell, Inc., Minneapolis, Minn.) and F. W. DeMoney (Kaiser Aluminum and Chemical Corp., Oakland, Calif.), p. 435, 436. 7 refs.
Contract No. NAS 8-5452.

Discussion of the development of higher-strength weldable aluminum alloys with good cryogenic toughness capable of being produced as plate with a room-temperature ultimate tensile strength of 65 ksi, and elongation of 10%. Two new alloys have been develope as high-strength candidates for cryogenic structure and tankage ap-

A66-37255 #
FACTORS INFLUENCING AIRCRAFT TURBINE ENGINE OIL DRAIN PRACTICES.
Donald W. Bedell (Humble Oil and Refining Co., Houston, Tex.).
(Society of Automotive Engineers, Automotive Engineering Congress Detroit, Mich., Jan. 10-14, 1966, Paper 660073.)
Esso Air World, vol. 18, May-June 1966, p. 148-152.

A66-37366 #
NIOBIUM-BASED SPRING ALLOY WITH AN ELASTIC MODULUS HIGHLY STABLE AT HIGH TEMPERATURES [PRUZHINNYI SPLAV NA OSNOVE NIOBIIA S VYSOKOI TEMPERATURNOI STABIL'NOST'IU MODULIA UPROGUSTI].

A. K. Borisova and B. G. Belov (Tsentral'nyi Nauchno-Issledovatel'skii Institut Chernoi Metallurgii, Moscow, USSR).
Metallovedenie i Termicheskaia Obrabotka Metallov, June 1966, p. 10, 11. In Russian.

Investigation of the mechanical properties of a Ni(55%)-Ti(39.5%)-Al(5.5%) alloy, one with an elastic-modulus temperature coefficient of (70 to 800) x 10^{-6}/°C at temperatures from 20 to 600°C. The hardness, toughness, stress relaxation, corrosion resistance and microstructure of the alloy are investigated. The alloy is assessed as a nonmagnetic corrosion-resistant high-quality spring material with a thermally stable elastic modulus. V. Z.

A66-37619
ROOM TEMPERATURE STRESS CORROSION CRACKING OF TITANIUM ALLOYS.
G. Sanderson and J. C. Scully (Leeds, University, Dept. of Metallurgy, Leeds, England).
Nature, vol. 211, July 9, 1966, p. 179.

Investigation demonstrating that stress corrosion cracking of a single phase α-titanium alloy (Ti-5Al-2.5 Sn) in 3% solutions of NaCl does not require fine surface notches or fatigue cracks, and can occur readily on flat chemically polished sheet specimens at room temperature. Sheet specimens of this chemically polished alloy were bent into a curved shape while immersed in a 3% NaCl solution acidified with HCl to a pH of 0.75, and then clamped. Within 6 weeks, transgranular cracks developed on the outer surface of the bend, while unpolished samples showed no signs of cracking even after 3 months. It is believed that hydride formation is part of the cracking mechanism; the importance of surface preparation in determining susceptibility is especially emphasized. M. L.

A66-37700
EFFECT OF WATER VAPOR ON THE FRICTION OF MOLYBDENUM DISULFIDE.
A. J. Haltner and C. S. Oliver (General Electric Co., Research Laboratory, Schenectady, N. Y.).
I & EC - Industrial and Engineering Chemistry, Fundamentals, vol. 5, Aug. 1966, p. 348-355. 25 refs.

A detailed study has been made of the effect of water vapor on the friction of an MoS_2 compact sliding against a rubbed film of MoS_2 on copper in an atmosphere of nitrogen. Associated with the friction increase in the presence of water vapor is a surface oxidation of MoS_2 to produce H_2S. The data are consistent with a picture which assumes that frictional forces arise from processes that occur at the surfaces of MoS_2 crystallites. The variation of friction of MoS_2 with the partial pressure of water vapor can be expressed by an equation which is derived using the shear strength theory of friction and the mathematical form of an adsorption isotherm. (Author)

A66-37801
A DISCUSSION ON DEFORMATION OF SOLIDS BY THE IMPACT OF LIQUIDS, AND ITS RELATION TO RAIN DAMAGE IN AIRCRAFT AND MISSILES, TO BLADE EROSION IN STEAM TURBINES, AND TO CAVITATION EROSION; ROYAL SOCIETY OF LONDON, MEETING, LONDON, ENGLAND, MAY 27, 1965.
Royal Society (London), Philosophical Transactions, Series A, vol. 260, July 28, 1966. 243 p.
$25.

CONTENTS:

HIGH SPEED LIQUID IMPACT. J. H. Brunton (Cambridge, University, Cambridge, England), p. 79-85, 109-120. 14 refs. [See A66-37802 20-18]

STRESS WAVES, DEFORMATION AND FRACTURE CAUSED BY LIQUID IMPACT. J. E. Field (Cambridge, University, Cambridge, England), p. 86-93, 109-120. 15 refs. [See A66-37803 20-18]

THE FORMATION OF MICROJETS IN LIQUIDS UNDER THE INFLUENCE OF IMPACT OR SHOCK. F. P. Bowden (Cambridge, University, Cambridge, England), p. 94, 95, 109-120. [See A66-37804 20-12]

OBLIQUE IMPACT OF A JET ON A PLANE SURFACE. Geoffrey Taylor (Cambridge, University, Cambridge, England), p. 96-100, 109-120. [See A66-37805 20-12]

THE APPLICATION OF DISLOCATION ETCHING TECHNIQUES TO THE STUDY OF LIQUID IMPACTS. K. H. Jolliffe (Central Electricity Generating Board, Leatherhead, Surrey, England), p. 101-120. 13 refs. [See A66-37806 20-12]

THE EROSION OF SOLIDS BY THE REPEATED IMPACT OF LIQUID DROPS. N. L. Hancox and J. H. Brunton (Cambridge, University, Cambridge, England), p. 121-139, 150-152. 21 refs. [See A66-37807 20-17]

THE INITIAL STAGES OF DEFORMATION IN METALS SUBJECTED TO REPEATED LIQUID IMPACT. G. P. Thomas (Cambridge, University, Cambridge, England), p. 140-143, 150-152. 5 refs. [See A66-37808 20-17]

DISINTEGRATION OF RAINDROPS BY SHOCKWAVES AHEAD OF CONICAL BODIES. D. C. Jenkins (Ministry of Aviation, Farnborough, Hants., England), p. 153-160, 179-181. 6 refs. [See A66-37809 20-02]

RAIN EROSION PROPERTIES OF MATERIALS. H. Busch, G. Hoff, and G. Langbein (Dornier-System GmbH, Friedrichshafen, West Germany), p. 168-181. 16 refs. [See A66-37810 20-18]

THE COLLAPSE OF CAVITATION BUBBLES AND THE PRESSURES THEREBY PRODUCED AGAINST SOLID BOUNDARIES. T. B. Benjamin and A. T. Ellis (Cambridge, University, Cambridge, England), p. 221-240, 276-294. 37 refs. [See A66-37811 20-12]

SHOCKWAVES FROM CAVITY COLLAPSE. M. S. Plesset (California Institute of Technology, Pasadena, Calif.), p. 241-244, 276-294. 14 refs. [See A66-37812 20-12]

DAMAGE TO SOLIDS CAUSED BY CAVITATION. F. G. Hammitt (Michigan, University, Ann Arbor, Mich.), p. 245-255, 276-294. 26 refs. [See A66-37813 20-17]

PRACTICAL ASPECTS OF CAVITATION. J. M. Hobbs (Ministry of Technology, Glasgow, Scotland), p. 267-294. 12 refs. [See A66-37814 20-18]

A66-38296 #
COMPARATIVE ESTIMATE OF THE EFFECTS OF ADDITIVES ON JET PROPELLANTS [SRAVNITEL'NAIA OTSENKA DEISTVIIA PRISADOK DLIA REAKTIVNYKH TOPLIV].
Ia. B. Chertkov and V. M. Ignatov.
Khimiia i Tekhnologiia Topliv i Masel, vol. 11, June 1966, p. 53-56. 6 refs. In Russian.

Investigation of the effect of additions of (1) 2,6-di-tert-butyl-4-methylphenol (ionol, topanol O), (2) n-hydroxy diphenylamine, (3) a copolymer of methacrylic acid with β-diethylethanolamine and lauryl alcohol (FOA-2), and (4) an "Esso" additive (a C_{21} aliphatic amine with a tertiary carbon atom in the alkyl radical) on the performance of some jet propellants. Corrosion effects and the oxidation resistance of propellants with these additives are discussed. V. Z.

A66-38382 #
PURIFICATION BY HYDROGENATION OF TURBINE OIL PREVIOUSLY REFINED WITH PHENOL [GIDROOCHISTKA TURBINNOGO MASLA FENOL'NOI OCHISTKI].
D. L. Gol'dshtein, K. M. Badyshtova, G. I. Iastrebov, N. B. Zhadanovskii, E. A. Alfimova, A. I. Pisarchik, E. A. Eminov, N. G. Laz'ian, and E. A. Mirzoeva.
Khimiia i Tekhnologiia Topliv i Masel, vol. 11, July 1966, p. 18-20. In Russian.

Discussion of the results of purification of turbine oil by a hydrogenation process at 325°C and 40 atmospheres, using an Al-Co-Mo catalyst. The advantages of this process over the contact purification process with commercial clay are noted. V. Z.

A66-38445 #
ADDITIVES IN OILS FOR USE IN HIGH-RPM JET ENGINES [ADITIVACE OLEJŮ PRO POTŘEBU RYCHLOBĚŽNÝCH PROUDOVÝCH MOTORŮ].
Jan Krotký.
Zpravodaj VZLÚ, no. 1, 1966, p. 43-48. 8 refs. In Czech.

Consideration of the possibilities of improving the properties of lubricating oils for use in high-RPM jet and turboprop engines. The effect of additives on the antioxidant stability and antiabrasion characteristics of the oils is described. Experimental results are given, and the optimum quantities of antioxidant and antiabrasion additives are determined. Performance data on the various types of oils with the examined additives in various proportions, under various experimental conditions, are tabulated and graphed. M. L.

A66-38471

STRESS-CORROSION CRACKING OF ALUMINIUM.

A. J. Jacobs (North American Aviation, Inc., Rocketdyne Div., Research Dept., Materials Section, Canoga Park, Calif.).

Nature, vol. 211, July 23, 1966, p. 403, 404.

Establishment of a fundamental relationship between those aluminum structures within a single aluminum forging alloy (achieved by heat treating) that are highly sensitive to stress-corrosion cracking and those that are immune. Thin-film transmission electron microscopy shows that Al-Zn-Mg-Cu 7075 alloy is susceptible to stress-corrosion failure in the -T6 temper (highest strength condition), but completely immune to cracking in the -T76 temper (low strength condition). Micrographs (two of which are included) show that the -T6 structure contains dislocation networks that are absent in the -T76 temper. Because pitting proceeds identically in both tempers (namely, by the dissolution of large $MgZn_2$ precipitate particles in the grain boundaries), it is concluded that the critical role of dislocations is to assist in the nucleation of cracks of appropiate geometry for propagation. M. L.

A66-38497 #

FACTORS AFFECTING THE VISCOSITY OF LUBRICANTS AT LOW TEMPERATURES.

I. N. Duling, J. Q. Griffith, III, and R. S. Stearns (Sun Oil Co., Research and Development Div., Marcus Hook, Pa.).

American Society of Mechanical Engineers, Design Engineering Conference and Show, Chicago, Ill., May 9-12, 1966, Paper 66-MD-68. 10 p. 19 refs.
Members, $0.75; nonmembers, $1.50.

Review of some solutions offered for the problem of obtaining minimum changes in the viscosity of liquid lubricants with temperature. The theoretical limits of each approach are indicated. The development of a class of excellent low-temperature lubricating oils is discussed as a unique solution to the problem of low-temperature lubrication. M. F.

A66-38799

CORROSION PROBLEMS WITH SIMULATED FUEL IN LAUNCH VEHICLE MODELS.

Clemans A. Powell, Jr. and Harland F. Scholl (NASA, Langley Research Center, Hampton, Va.).

Materials Protection, vol. 5, Aug. 1966, p. 33, 34.

Outline of corrosion problems experienced with propellant simulants and of the steps taken to correct them. The following measures are being used to minimize the corrosion of launch-vehicle models in structural dynamic studies: (1) only corrosion-resistant alloys are used in constructing models, and care is taken to prevent galvanic action between dissimilar metals which come in contact with fuel simulants; (2) surface treatments of the construction material are considered, and coatings used when necessary; (3) frequent inspections of tank systems and storage containers are made. Measures being used to minimize any corrosive properties of the propellant simulants are: (1) chemical properties of the simulants are determined, including basic properties and changes which can occur because of absorption of the water and gases used for tank pressurization; (2) if such changes are possible, appropriate filters and additives are used; and (3) the properties of the simulants are frequently monitored. M. M.

A66-39234

RECENT DEVELOPMENTS IN HIGH STRENGTH ALUMINIUM ALLOYS.

W. A. Baker (Alcan Industries, Ltd., London, England), A. J. Bryant, R. J. Durham, and R. W. Elkington (Aluminium Laboratories, Ltd., Banbury, Oxford, England).

(Royal Aeronautical Society, Symposium on Metallic Materials, London, England, Jan. 19, 1966, Paper.)
Royal Aeronautical Society, Journal, vol. 70, Aug. 1966, p. 757-763; Discussion, p. 799-801. 23 refs.

Study of efforts to improve strong aluminum alloys. Interest is centered on two main groups of heat-treatable alloys, namely Al-Cu-Mg-Si alloys in the first group, and Al-Zn-Mg-Cu alloys in the second. Characteristics of strong alloys are discussed, and the tensile strength, toughness, and stress-corrosion resistance of these improved materials are evaluated. Values representing typical properties of strong aluminum alloys and average tensile properties of strong alloy plate are tabulated. B. B.

A66-39325 #

POSSIBILITY OF USING A GYROVERTICAL UNDER ITS STARTING CONDITIONS [O VOZMOZHNOSTI ISPOL'ZOVANIIA GIROVERTIKALI V REZHIME EE ZAPUSKA].

M. A. Pavlovskii (Kievskii Politekhnicheskii Institut, Kiev, Ukrainian SSR).

Priborostroenie, vol. 9, no. 3, 1966, p. 79-84. In Russian.

Study of the effect of friction and imbalance moments relative to the gimbal axes on the motion of a gyrovertical under starting conditions. It is shown that, by introducing a device which delays the uncaging of the gyrovertical with respect to the moment it is switched on, a possibility of using the gyrovertical under its starting conditions is created. A gyrovertical on a stationary base is considered. A. B. K.

A66-39333 #

REDUCTION OF FRICTION IN INSTRUMENT BEARINGS [K VOPROSU OB UMEN'SHENII TRENIIA V OPORAKH PRIBOROV].

I. M. Sivokonenko, K. N. Iavlenskii, and L. V. Semenov (Leningradskii Institut Aviatsionnogo Priborostroeniia, Leningrad, USSR).

Priborostroenie, vol. 9, no. 3, 1966, p. 141-144. In Russian.

Experimental investigation of the moment of friction forces in radial-thrust bearings and three-point-contact bearings with compulsory motion of the outer and inner races. A qualitative analysis is given of the reduction of friction when the compulsary oscillations of the outer and inner races have the same direction in both bearings. V. P.

A66-39528 #

THE PLASTIC BENDING OF BEAMS CONSIDERING DIE FRICTION EFFECTS.

G. Martin and S. Tsang (North American Aviation, Inc., Los Angeles, Calif.).

(American Society of Mechanical Engineers, Aviation and Space Conference, Los Angeles, Calif., Mar. 14-18, 1965, Paper.)
ASME, Transactions, Series B - Journal of Engineering for Industry, vol. 88, Aug. 1966, p. 237-250. 19 refs.
Research supported by the North American Aviation Research Program.

This paper describes a theoretical and experimental analysis of the behavior of simple beams bent by a central load while freely supported at each end. Both plane strain and plane stress conditions and the effect of friction at the beam supports are considered. Materials tested are SAE 4130 steel and titanium 6Al-4V alloy. It is concluded that in beams whose length between supports is at least 25 times their thickness the load required to effect deflection is increased by the amount required to overcome friction, but does not affect the circumferential strain at midspan. Theoretical methods of analysis correlate well with experimental results and allow the computation of stresses and strains from the beam geometry and true tensile curves of the materials. (Author)

A66-39668 #
NEW ASPECTS ABOUT COULOMB FRICTION AS APPLIED TO MECHANISM DESIGN.
J. Boas Popper (Ministry of Defence, Tel Aviv, Israel).
(Israel Conference on Theoretical and Applied Mechanics, 13th, Haifa, Israel, June 28, 1965, Paper.)
Israel Journal of Technology, vol. 3, Sept. 1965, p. 164-172. 7 refs.
Research sponsored by the Israel Ministry of Defence.

Review of new results derived from the analysis of a general two-wedge system where the coefficient of friction varies. The basic model of friction mechanisms is described. Practical examples include the high-pitch self-locking screw, the overload slip clutch, the maximum efficiency screw, three kinds of self-locking mechanism, a spherical wedge combination, and locking high-efficiency screws. M.F.

A66-40040 #
THE FIELD CLEANING OF CORROSION-RESISTANT STEEL TUBING FOR LOX AND PNEUMATIC SERVICE.
Janus Y. Ellenburg (Hayes International Corp., Birmingham, Ala.).
American Association for Contamination Control, Annual Technical Meeting and Exhibit, 5th, Houston, Tex., Mar. 29-Apr. 1, 1966, Paper. 4 p.
Contract No. NAS 8-2483.

Study to evaluate media and processes for Cleaning Procedure 3 for corrosion-resistant steel tubing for LOX and pneumatic service. The excessively high solution temperature and highly alkáline trisodium phosphate specified in the procedure created many technical and economic problems. Two test facilities (a laboratory pumping station and a closed-loop field pumping station) were built for this program. Experimental procedures and conditions imposed on design of a cleaning formula are described. The final cleaning formula obtained was a blend of phosphoric acid, butyl cellosolve, and an alkyl aryl polyethylene glycol surfactant in water. W.A.E.

A66-40216 #
EVALUATION OF LUBRICANTS AT HIGH AND LOW TEMPERATURES IN ULTRAHIGH VACUUM.
L. E. McCrary, T. P. Bradley, and J. W. Parks (McDonnell Aircraft Corp., St. Louis, Mo.).
IN: AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, INSTITUTE OF ENVIRONMENTAL SCIENCES, AND AMERICAN SOCIETY FOR TESTING AND MATERIALS, SPACE SIMULATION CONFERENCE, HOUSTON, TEX., SEPTEMBER 7-9, 1966. TECHNICAL PAPERS. [A66-40204 22-11]
New York, American Institute of Aeronautics and Astronautics, 1966, p. 91-96. 9 refs.
Contract No. NAS 9-170.

An apparatus in which the wear life and the coefficient of friction of dry film lubricants, solid film lubricants, and plastic materials can be measured is described. Features of the test apparatus are: environmental pressures of less than 1×10^{-8} torr at specimen temperatures from -150°F to 400°F; normal loads from 0 to 600 lb; and automatic control of long-term tests. The Timken line-contact method of lubricant testing is used. Data are presented for a large number of commercially available lubricants. The metal films and the plastic materials tested do not have long wear lives or high load carrying ability. Some molybdenum disulfide-based lubricants have greater than 24-hr wear lives in vacuum at either high or low temperature and under high loads. (Author)

A66-40221 #
CRYOPANEL CORROSION AND COATING DEGRADATION IN SPACE CHAMBER PROPULSION TESTING.
P. G. Waldrep (ARO, Inc., Arnold Engineering Development Center, Aerospace Environmental Facility, Arnold Air Force Station, Tenn.).
IN: AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, INSTITUTE OF ENVIRONMENTAL SCIENCES, AND AMERICAN SOCIETY FOR TESTING AND MATERIALS, SPACE SIMULATION CONFERENCE, HOUSTON, TEX., SEPTEMBER 7-9, 1966. TECHNICAL PAPERS. [A66-40204 22-11]
New York, American Institute of Aeronautics and Astronautics, 1966, p. 127-137. 10 refs.

Pitting of 300-series stainless steel, uncoated and coated with a black epoxy film, was found to occur when samples were exposed to nitrogen tetroxide under space chamber conditions with temperature cycling from 77°K to ambient conditions. Some degradation of the organic coating was found. Intergranular corrosion of welded stainless steel 304 was detected. These results indicate that propulsion systems testing in space simulation chambers will produce an environment conducive to corrosion of metal chamber components at a rate which at present cannot be stated. The variables encountered in corrosion rate studies are discussed and suggestions for future work made. (Author)

A66-40657
PERFORMANCE OF HIGH SPEED BALL BEARINGS WITH JET OIL LUBRICATION.
R. J. Matt (Fafnir Bearing Co., New Britain, Conn.) and R. J. Giannotti (General Motors Corp., New Departure-Hyatt Bearings Div., Bristol, Conn.).
(American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 1B4.)
Lubrication Engineering, vol. 22, Aug. 1966, p. 316-323; Discussion, L.B. Sibley, F. R. Morrison (SKF Industries, Inc., Research Laboratory, King of Prussia, Pa.), J. A. Mauriello (Avco Corp., Lycoming Div., Stratford, Conn.), and P. F. Brown (United Aircraft Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.), p. 323-325; Authors' Closure, p. 325, 326. 5 refs.
Contracts No. NASw-492; No. NAS 3-6267.
[For abstract see issue 16, page 2710, Accession no. A66-30402]

A66-40679
CORROSION FATIGUE STRENGTH OF DURALUMIN IN THE PRESENCE OF STRESS CONCENTRATORS.
A. V. Karlashov and Iu. V. Tomnikov (Kievskii Institut Grazhdanskogo Vozdushnogo Flota, Kiev, Ukrainian SSR).
(Fiziko-Khimicheskaia Mekhanika Materialov, vol. 1, Mar.-Apr. 1965, p. 188-192.)
Soviet Materials Science, vol. 1, Mar.-Apr. 1965, p. 126-129. 11 refs. Translation.

Experimental investigation of the fatigue properties of a D16T alloy of a particular chemical composition. The results obtained showed that: (1) the conditional endurance limit is markedly reduced by stress concentrators, 2.5 times by sharp notches and 1.25 times by radiused recesses; (2) the conditional corrosion endurance limit depends on the geometry of stress concentrators, the activity of the corrosive media, and the test base; (3) the effects of stress concentrators and corrosive media on the fatigue properties of the D16T alloy are not cumulative; and (4) the conditional corrosion endurance limit of notched specimens decreases with decreasing fracture probability. M.M.

A66-40680
EFFECT OF HEAT TREATMENT ON THE STRUCTURE, MECHANICAL PROPERTIES, AND CORROSION CHARACTERISTICS OF VTZ-1 ALLOY.
A. V. Boltarovich, V. I. Pokhmurskii, K. P. Tabinskii, and V. P. Shportko (Akademiia Nauk Ukrainskoi SSR, Fiziko-Mekhanicheskii Institut, Lvov, Ukrainian SSR).
(Fiziko-Khimicheskaia Mekhanika Materialov, vol. 1, Mar.-Apr. 1965, p. 209-213.)
Soviet Materials Science, vol. 1, Mar.-Apr. 1965, p. 142-145. Translation.

Experimental investigation of the effects of heat treatment on the structure, mechanical properties, and corrosion resistance of VTZ-1 alloy. The results obtained showed that the mechanical and corrosion characteristics of this alloy are substantially affected by both the temperature and duration of annealing. The highest values of the mechanical properties and resistance to corrosion correspond to annealing at 600°C; the lowest resistance to corrosion corresponds to annealing at 700°C. When the usually recommended aging temperature of 500°C was employed, the mechanical properties of the alloy reached their maximum values after 2 hr, the resistance of

the alloy to the corrosive action of sulfuric acid being at its highest after 2 to 5 hr of aging. M.M.

A66-40877 #

PROPERTIES OF VAD23 ALLOY [SVOISTVA SPLAVA VAD23].
I. N. Fridliander, O. A. Romanova, and Z. N. Archakova.
IN: ALUMINUM ALLOYS. ISSUE 4 - HEAT-RESISTANT AND HIGH STRENGTH ALLOYS [ALIUMINIEVYE SPLAVY. VYPUSK 4 - ZHAROPROCHNYE I VYSOKOPROCHNYE SPLAVY].
Edited by I. N. Fridliander.
Moscow, Izdatel'stvo Metallurgiia, 1966, p. 5-14. 13 refs. In Russian.

Discussion of the structural, mechanical, and corrosion properties of Al-Cu-Li-Cd-Mn based VAD23 alloy of various compositions. The effect of variations in the proportion of individual components on the properties of the alloy is investigated. The suitable composition is given as 4.9 to 5.8% Cu, 1.0-1.4% Li, 0.1 to 0.25% Cd, 0.4 to 0.8% Mn, Fe and Si $\leq$ 0.3%, and Ti $\leq$ 0.15%. V.Z.

A66-41293 #

ON THE LOAD SUPPORTING CAPACITY OF A VERTICAL PLASMA CYLINDER.
Gundala Ramanaiah (Institute of Technology, Dept. of Applied Mathematics, Kharagpur, India).
Japanese Journal of Applied Physics, vol. 5, Aug. 1966, p. 730. 5 refs.

Discussion of the load-supporting capacity of a vertical plasma cylinder held in shape by the axial pinch effect. The voltage applied creates an electric current in the cylinder that is assumed to be uniformly distributed over the cross section of the cylinder. The current flowing parallel to the cylinder axis excites a magnetic field in the azimuthal direction. The gas pressure in the plasma is determined by the equality of the gas-pressure gradient to the ponderomotive force at any point. The geometry of the cylinder is simple, but it requires a high current density. The inherent instability of the pinch effect and the difficulties encountered at the electrodes must also be overcome for successful application. W.A.E.

A66-41409 #

BREAKDOWN CAUSED BY A LASER BEAM IN TRANSPARENT DIELECTRICS [O RAZRUSHENIIAKH, VYZYVAEMYKH LAZERNYM PUCHKOM V PROZRACHNYKH DIELEKTRIKAKH].
B. M. Ashkinadze, V. I. Vladimirov, V. A. Likhachev, S. M. Ryvkin, V. M. Salmanov, and I. D. Iaroshetskii (Akademiia Nauk SSSR, Fiziko-Tekhnicheskii Institut, Leningrad, USSR).
Akademiia Nauk SSSR, Doklady, vol. 169, Aug. 11, 1966, p. 1041-1043. In Russian.

Study of the effects of a laser beam on hydrodynamic bearings made of polymethyl methacrylate, alkali-haloid crystals, and glass. Microcracks and other breakdowns caused by ordinary and giant pulses of coherent light from a laser are discussed. The critical energy observed was adequate to explain the beginning of breakdown as being caused by light pressure, electric breakdown, thermal heating, a shock wave, or similar effects. Failure of the materials under coherent hypersonic phonons may account for certain puzzling effects noted during the experiments. Heat explosion may be an important secondary effect near the focus of the laser beam. Breakdown under powerful light beams may be used to compare volumetric and surface strength. W.A.E.

A66-41658

USE OF MOLYBDENUM BISULFIDE IN THE AIRCRAFT AND AEROSPACE INDUSTRIES [EMPLOI DU BISULFURE DE MOLYBDENE DANS LES INDUSTRIES AERONAUTIQUES ET SPATIALES].
P. Bessière (Société Molykote Française, Département Recherches et Applications, France).
La Technique Moderne, vol. 57, May 1965, p. 269-271. 7 refs. In French.

Application of molybdenum bisulfide as a lubricant in the construction of aircraft and spacecraft. In the case of aircraft molybdenum bisulfide is used mainly to combat fretting corrosion, facilitate assembly and dismantling of parts, and ultimately reduce the frequency of maintenance. Examples of the application of high-concentration molybdenum bisulfide slipping varnishes and pastes on Potez, Breguet, and Dassault aircraft are cited. The problems posed by satellites, missiles, and spacecraft are referred to, together with some of the solutions adopted in the U.S. A.B.K.

A66-41659

HARD ANODIZATION AND DOW 17 AS APPLIED TO MATRA MISSILES [L'ANODISATION DURE ET LE DOW 17 EN APPLICATION AUX ENGINS MATRA].
M. Gazaniol (MATRA, S.A., Paris, France).
La Technique Moderne, vol. 57, May 1965, p. 272. In French.

Description of two techniques for increasing the corrosion resistance of missile components made of aluminum and magnesium alloys. The use of the technique of hard anodic oxidation is illustrated in the case of an aluminum-alloy airborne-missile component. It is shown that magnesium-alloy components can be successfully protected from corrosion by subjecting them to the Dow 17 treatment (a type of anodic oxidation) and then coating them with Araldite 985 E varnish. A.B.K.

A66-41736 #

INVESTIGATION OF THE BASIC CHARACTERISTICS OF A MAGNETOHYDRODYNAMIC BEARING [ISSLEDOVANIE OSNOVNYKH KHARAKTERISTIK MAGNITOGIDRODINAMICHESKOGO PODSHIPNIKA].
I. A. Shvarts.
Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza, July-Aug. 1966, p. 189-191. 5 refs. In Russian.

Calculation of the carrying capacity and moment of friction of a cylindrical magnetohydrodynamic bearing. The calculations are performed for known boundaries of the lubricating layer and a small magnitude of radial clearance. The presence of an external magnetic field directed along the axis of the bearing and of a radial electric field leads to a considerable increase in the carrying capacity of the conducting boundary layer. The condition is found at which the moment of friction on the pivot of the MHD bearing tends toward zero. W.A.E.

A66-41870 #

SOLID LUBRICANTS FOR EXTREME ENVIRONMENTS.
Harold E. Sliney (NASA, Lewis Research Center, Cleveland, Ohio).
Rensselaer Polytechnic Institute, Seminar on Solid Lubricants, Troy, N.Y., Aug. 29-Sept. 1, 1966, Paper. 28 p. 18 refs.

Demonstration that solid lubricants can be effectively used in many difficult lubrication problem areas. The lamellar crystal structure solid lubricants, such as MoS_2, usually give good results when properly used in environments where they are chemically and physically stable. For those environments with which the well known lamellar solid lubricants are not compatible, ceramic, glaze, or salt materials can often be formulated into coatings or composites that provide satisfactory lubrication. Advantages and disadvantages of solid lubricants are compared, especially the advantage of low shear strength. Graphite, MoS_2, WS_2, and various fluorides - e.g., CaF_2 - are compared. M.L.

A66-42579 ≐

LUBRICATION REVIEW.
C. L. Hingley (SKF Industries, Inc., Research Laboratory, King of Prussia, Pa.), R. F. Zogbaum, Jr. (United Aircraft Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.), H. J. Sneck (Rensselaer Polytechnic Institute, Troy, N.Y.), C. N. Rowe (Socony Mobil Oil Co., Princeton, N.J.), R. C. Bowers (U.S. Naval Research Laboratory, Washington, D.C.), W. J. Wojtowicz (H. A. Montgomery Co., Detroit, Mich.), and Vern Hopkins (Midwest Research Institute, Kansas City, Mo.).
ASME, Transactions, Series D - Journal of Basic Engineering, vol. 88, Sept. 1966, p. 599-623. 416 refs.

Digest of the literature on lubrication published in 1964. Rolling-element bearings are discussed in the literature from the standpoints of kinematics, contact stresses, rolling and sliding friction, elastohydrodynamics and wear, rolling-contact fatigue, bearing vibration and lubrication, materials and manufacture, and application and design. Materials published on gear lubrication include discussions of numerous types of gears operating under the most diverse conditions. Papers on fluid-film bearings include several general surveys and specific materials on self-acting bearings, externally pressurized bearings, and certain special types such as magnetohydrodynamic bearings. An extensive literature devoted to problems of boundary lubrication, friction and wear, metalworking and automotive lubricants, and developments in lubricants is reported. W.A.E.

A66-42700
CHEMICAL EFFECTS IN THE BOUNDARY LUBRICATION OF ALUMINUM.
L. E. St. Pierre (General Electric Co., Research Laboratory, Schenectady, N.Y.), R. S. Owens (General Electric Co., Schenectady, N.Y.), and R. V. Klint (General Electric Co., Power Transmission Div., Schenectady, N.Y.).
Wear, vol. 9, Mar.-Apr. 1966, p. 160-168. 13 refs.

The effect of chemical attachment in boundary lubrication is demonstrated by the relative lubricating properties on aluminum of 1-cetene and cetane in thrust washer experiments. The unreactive hydrocarbon cetane permitted galling and seizing of the aluminum to occur with high friction. However, the use of the reactive 1-cetene resulted in sliding taking place at low friction. The role of aluminum oxide particles and their relation to wear is discussed. The basic requirements for a good boundary lubricant for aluminum are shown to be (1) chemical attachment to the fresh aluminum surface formed in rubbing, (2) sufficient chain length, and (3) polarity to coat abrasive aluminum oxide wear particles. (Author)

A66-42701
ANISOTROPY IN THE MECHANICAL PROPERTIES OF LAMELLAR SOLIDS AND ITS EFFECT ON WEAR AND TRANSFER.
J. K. Lancaster (Ministry of Aviation, Royal Aircraft Establishment, Chemistry, Physics, and Metallurgy Dept., Farnborough, Hants., England).
Wear, vol. 9, May-June 1966, p. 169-188. 31 refs.

Experimental determination of the degree of anisotropy in mechanical properties of lamellar solids such as graphite, MoS_2, mica, PbI_2, etc. Radioactive measurements of the wear of copper which slides against compacts of lamellar solids, together with qualitative assessment of surface damage on other metals, show that many of the solids are intrinsically abrasive. The amount of wear and surface damage depends on the relative maximum hardness of the solid and the metal and, in addition, on the extent to which the lamellar solid acquires a preferred orientation during sliding. It is suggested that embedding of suitably oriented crystallites of a lamellar solid into metal surfaces is a major factor in the formation of transferred films of the solids. There is no evidence that chemical interactions play a significant role in the bonding of a solid lubricant film to its substrate. F.R.L.

A66-42702
THE FRICTION AND VISCO-ELASTIC PROPERTIES OF POLYMERIC SOLIDS.
K. C. Ludema and D. Tabor (Cambridge, University, Cavendish Laboratory, Cambridge, England).
Wear, vol. 9, Sept.-Oct. 1966, p. 329-348. 27 refs.
Research supported by the Ford Foundation and the University of Michigan.

Attempt to link the frictional properties of polymers with their viscoelastic characteristics. Results show that for rubber there is a close relation between (1) the sliding friction at various speeds and temperatures and (2) the viscoelastic properties of the rubber. With polymers below their glass transition temperature there was often a marked variation in sliding friction with speed and temperature, but it did not appear to correlate directly with the viscoelastic properties of these materials as determined by conventional methods. However, the rolling friction correlated very well with conventional viscoelastic data. The lack of correlation with sliding friction is attributed to the extremely high shear strains occurring at the interface during sliding. F.R.L.

A66-42772 #
MECHANICAL AND CHEMICAL CONTRIBUTIONS TO THE EROSION RATES OF GRAPHITE THROATS IN ROCKET MOTOR NOZZLES.
V. R. Gowariker (Imperial Metal Industries /Kynoch/, Ltd., Ballistics and Mathematical Services Dept., Summerfield Research Station, Kidderminster, Worcs., England).
(American Institute of Aeronautics and Astronautics, Annual Meeting, 2nd, San Francisco, Calif., July 26-29, 1965, Paper 65-351.)
Journal of Spacecraft and Rockets, vol. 3, Oct. 1966, p. 1490-1494. 6 refs.

A66-42844 ≐
VANISHING SLIDING MOTIONS OF MECHANICAL SYSTEMS WITH DRY FRICTION.
G. K. Pozharitskii.
(Prikladnaia Matematika i Mekhanika, vol. 29, May-June 1965, p. 558-563.)
PMM - Journal of Applied Mathematics and Mechanics, vol. 29, no. 3, 1965, p. 661-668. Translation.

1967
IAA ABSTRACTS

A67-10119 *
RESEARCH AND DEVELOPMENT OF MATERIALS FOR USE AS LUBRICANTS IN A LIQUID HYDROGEN ENVIRONMENT.
W. H. Rempe, Jr. (United Aircraft Corp., Pratt and Whitney Aircraft Div., Florida Research and Development Center, West Palm Beach, Fla.).
(American Society of Lubrication Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Paper.)
ASLE Transactions, vol. 9, July 1966, p. 213-220; Discussion, H. W. Scibbe and D. E. Brewe (NASA, Lewis Research Center, Cleveland, Ohio), p. 220; Author's Closure, p. 220, 221. 10 refs.
Contract No. NAS 8-11537.

A67-10120
LUBRICATION OF BALL BEARINGS WITH VOLATILE ORGANIC COMPOUNDS.
M. J. Devine, E. R. Lamson, L. Stallings, and L. P. Gilmore (U.S. Naval Air Engineering Center, Aeronautical Materials Laboratory, Philadelphia, Pa.).
(American Society of Lubrication Engineers, Lubrication Conference, San Francisco, Calif., Oct. 18-20, 1965, Paper.)
ASLE Transactions, vol. 9, July 1966, p. 242-246; Discussion, S. F. Murray (Mechanical Technology, Inc., Latham, N.Y.) and D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio), p. 247, 248; Authors' Closure, p. 248. 8 refs.

A67-10121
METHOD OF SELECTING AN OPTIMUM LUBRICANT TESTING SYSTEM.
Lee S. Akin (Douglas Aircraft Co., Inc., Santa Monica, Calif.).
(American Society of Lubrication Engineers, Annual Meeting, Pittsburgh, Pa., May 3-5, 1966, Paper.)
ASLE Transactions, vol. 9, July 1966, p. 249-256. 11 refs.

A67-10122
A THEORY OF LIQUID-SOLID HYDRODYNAMIC FILM LUBRICATION.
H. Grady Rylander (Texas, University, Mechanical Engineering Dept., Austin, Tex.).
(American Society of Lubrication Engineers, Annual Meeting, Pittsburgh, Pa., May 3-5, 1966, Paper.)
ASLE Transactions, vol. 9, July 1966, p. 264-271. 14 refs.
NSF-supported research.

A67-10546 #
INVESTIGATION OF TITANIUM ALLOYS UNDER COMPRESSOR OPERATING CONDITIONS [ISSLEDOVANIE SPLAVOV TITANA PRIMENITEL'NO K USLOVIIAM RABOTY KOMPRESSOROV].
B. M. Idel'chik and N. I. Belan.
Energomashinostroenie, vol. 12, Sept. 1966, p. 37-40. In Russian.
Investigation of the behavior of AT-3, AT-4, AT-6, and VT3-1 titanium alloys under operating conditions in aggressive media, as materials for compressor parts. The mechanical properties of disk-shaped forgings are tested at temperatures from 20 to 400°C. The corrosion resistance tests are conducted in nitrose- and SO_2 -containing media and in hydrocarbon/nitrogen oxides mixtures. A high corrosion resistance and adequate mechanical properties of samples are indicated. V. Z.

A67-10582
DESIGN OF STORABLE PROPELLANT PRESSURE VESSELS.
R. J. Heymans, E. D. Thompson, and L. D. Berman (Martin Marietta Corp., Martin Co., Baltimore, Md.).
Society of Automotive Engineers, Aeronautic and Space Engineering and Manufacturing Meeting, Los Angeles, Calif., Oct. 3-7, 1966, Paper 660677. 10 p.
Members, $0.75; nonmembers, $1.00.
Discussion of the developmental background of four considerations in the design of storable propellant structures in connection with the Titan family. These considerations are: (1) stress caused by load and pressure requirements, (2) sealing surfaces and bolted tank closures, (3) corrosion and stress corrosion, and (4) material compatibility. A comprehensive summary of the compatibility of materials with amine fuels and nitrogen tetroxide is given. The development of criteria and environments, the formulation of test procedures, the data applicable to compatibility of metals, nonmetallics, finishes, lubricants, and sealing systems for both airborne and ground equipment is discussed. Some mechanics of corrosion of aluminum in the amine fuels are also mentioned. S. Z.

A67-10601
LUBRICATION OF THE SST ENGINE.
J. A. Daley (United Aircraft Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.).
Society of Automotive Engineers, Aeronautic and Space Engineering and Manufacturing Meeting, Los Angeles, Calif., Oct. 3-7, 1966, Paper 660711. 6 p.
Members, $0.75; nonmembers, $1.00.
Review of the effect of the flight environment on the severity of the lubrication requirements of the Pratt and Whitney candidate SST engine and comparison of it with current commercial turbofan engines. The characteristics of currently available lubricants are examined. The design features of the SST engine aimed at reducing lubricant system stress are discussed. The conclusion is drawn that several Type II oils currently available will meet the requirements established by the SST engine. (Author)

A67-10602
LUBRICITY OF JET FUELS.
J. K. Appeldoorn and W. G. Dukek (Esso Research and Engineering Co., Linden, N.J.).
Society of Automotive Engineers, Aeronautic and Space Engineering, and Manufacturing Meeting, Los Angeles, Calif., Oct. 3-7, 1966, Paper 660712. 12 p. 18 refs.
Contract No. AF 33(615)-2828.
Comment on the fact that the poor performance of some high purity jet fuels appears to be related to polar compounds in the fuel and not to viscosity, volatility, or sulfur and nitrogen compounds. Surface active additives such as corrosion inhibitors markedly improve lubricity. Results of laboratory tests correlate well with the field experience, where sticking fuel controls and pump wear at high temperatures have been reported. Highly refined fuels developed to meet new standards of thermal stability or purity are generally poor in lubricity compared with conventionally refined fuels and may require lubricity additive to satisfy advanced fuel systems. (Author)

A67-10708
PRODUCTION AND PROPERTIES OF A NEW POROUS BEARING.
H. Youssef and M. Eudier (Metafram, Beauchamp, Seine-et-Oise, France).
IN: MODERN DEVELOPMENTS IN POWDER METALLURGY; PROCEEDINGS OF THE INTERNATIONAL POWDER METALLURGY CONFERENCE, NEW YORK, N.Y., JUNE 14-17, 1965. VOLUME 3 - DEVELOPMENT AND FUTURE PROSPECTS. [A67-10706 01-17]
Conference sponsored by the Metal Powder Industries Federation, the American Powder Metallurgy Institute, and the Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers.
Edited by H. H. Hausner.
New York, Plenum Press, Division of Plenum Publishing Corp., 1966, p. 129-137. 5 refs.
The behavior of ordinary bearings is described with varied conditions for geometrical factors, diameter, length, clearance, running speed, and for the oil quality, temperature and load. The essential feature of the new bearings is that they have inside of the bore a layer of ultrafine powder. The manufacturing process is described. Maximum loads which are permissible are indicated as functions of the same parameters as for ordinary bearings. Conclusions are drawn to improve the utilization of porous bearings. (Author)

A67-10710
SINTERED-METAL FRICTION MATERIALS.
Ben T. Collins and C. P. Schneider (Raybestos-Manhattan, Inc., Wabash Div., Crawfordsville, Ind.).
IN: MODERN DEVELOPMENTS IN POWDER METALLURGY; PROCEEDINGS OF THE INTERNATIONAL POWDER METALLURGY CONFERENCE, NEW YORK, N.Y., JUNE 14-17, 1965. VOLUME 3 - DEVELOPMENT AND FUTURE PROSPECTS. [A67-10706 01-17]
Conference sponsored by the Metal Powder Industries Federation, the American Powder Metallurgy Institute, and the Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers.
Edited by H. H. Hausner.
New York, Plenum Press, Division of Plenum Publishing Corp., 1966, p. 160-165. 10 refs.
Sintered-metal friction materials are produced from a mixture of metallic and nonmetallic powders and have quite complex compositions. They must contain a matrix or binder alloy, which is either copper or iron base and a friction agent. In addition they may contain solid lubricants, wear-resistant agents, and fillers. The powder mixture is cold-compacted at a pressure of 12 to 18 tons/$in.^2$. The compacts are usually sintered under pressure and simultaneously bonded to a steel backing. The various types of friction materials for dry and wet friction, for dynamic and static, and for mild and severe applications are described. Friction materials are evaluated by determining such characteristics as dynamic and static coefficients of friction, the ratio of these coefficients, energy capacity and durability, wear behavior, fabricability, and cost. (Author)

A67-10726 *
THE CHANGING TECHNOLOGY OF ROLLING-ELEMENT BEARINGS.
Erwin V. Zaretsky (NASA, Lewis Research Center, Bearing Materials and Fatigue Section, Cleveland, Ohio).
Machine Design, vol. 38, Oct. 13, 1966, p. 206-216, 218, 219, 222, 223.

Discussion of the advanced technology of materials, materials processing, and design of components of special bearings for other than standard needs. Effect of nonmetallic inclusions on rolling-element fatigue and the vacuum melting method of getting rid of contaminants are mentioned. The ausforming technique of increasing bearing life by as much as 600 to 700% is reviewed. Residual stresses which induce surface stresses are considered, and the effects of component hardness on fatigue life of rolling-element systems are described. The question of fiber orientation in parallel forging is briefly examined. S.Z.

A67-10728
ELASTOHYDRODYNAMIC LUBRICATION.
L. B. Sibley (SKF Industries, Inc., Mechanical Test Section, King of Prussia, Pa.).
Machine Design, vol. 38, Oct. 13, 1966, p. 220, 221.

Note on the role of elastohydrodynamic (EHD) lubrication in rolling bearings in avoiding oil-film breakdown in the contact zone. Significant increases in the fatigue life of both ball and roller bearings with increases in speed of operation are attributed to the resulting increases in EHD film parameter (ratio of EHD film thickness to composite roughness of contacting surfaces). The question of minimum EHD films and the simplified EHD computation method are reviewed. S.Z.

A67-11012
CORROSION AND THE P-3 ORION.
E. L. Grindle (Lockheed Aircraft Corp., Lockheed California Co., Burbank, Calif.).
Lockheed Service Digest, Aug. 1966, p. 3-6.

Discussion of the corrosion-control requirements of the P-3 Orion aircraft with a view to preventing corrosion from gaining a foothold on the P-3 aircraft. Six steps are recommended for every approach to corrosion control, whether general or specific, and the corrosion control measures to be followed after the discovery of corrosion are tabulated. M.M.

A67-11246 #
STUDY OF THE ANTIFRICTION PROPERTIES OF SOME COMPOSITIONS OF COMPACTING CERMET MATERIALS. II [ISSLEDOVANIE ANTIFRIKTSIONNYKH SVOISTV NEKOTORYKH KOMPOZITSII METALLOKERAMICHESKIKH UPLOTNITEL'NYKH MATERIALOV. II].
M. E. Belitskii (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukrainian SSR).
Poroshkovaia Metallurgiia, vol. 6, Sept. 1966, p. 61-66. In Russian.

Results of a study of the effect of lubrication on the friction behavior of cermet materials composed of nickel and graphite, nickel and boron nitride, nickel and mica, nickel and zinc oxide, nichrome and mica, and nichrome and boron nitride. Solid lubricants in amounts exceeding 20 vol % are found to increase the friction coefficient and wear. Phlogopite and boron nitride are suggested as substitutes for graphite lubricants. V.Z.

A67-12218
CORROSION DETECTION WITH A BETA RADIATION PROBE.
Charles O. Badgett (Industrial Nucleonics Corp., Columbus, Ohio).
IN: RADIOISOTOPES FOR AEROSPACE; PROCEEDINGS OF THE FIRST SYMPOSIUM ON RADIOISOTOPE APPLICATIONS IN AEROSPACE, DAYTON, OHIO, FEBRUARY 15-17, 1966. PART 1 - ADVANCES AND TECHNIQUES. [A67-12207 02-14]
Symposium sponsored by the U.S. Air Force, the U.S. Atomic Energy Commission, and the Instrument Society of America.
Edited by J. C. Dempsey and Paul Polishuk.
New York, Plenum Press, Division of Plenum Publishing Corp., 1966, p. 274-296. 6 refs.
Contract No. NOw-64-0551-f.

Investigation of the detection of corrosion of a metal surface under a protective coating with a beta radiation probe. When metal surfaces of the structural members of an aircraft are protected by a coating such as epoxy resin, it becomes difficult to detect any corrosion of the surface without removing the coating. Tests show that corrosion products can be identified with beta particles when the corrosion lies on the surface of the aluminum substrate beneath an epoxy/polyamide protective coating. Incipient corrosion can be detected even if the protective coating varies in thickness. W.A.E.

A67-12221
THE USE OF A SIMPLIFIED NEUTRON ACTIVATION TECHNIQUE FOR ANALYZING METALLIC WEAR FROM AIRCRAFT HYDRAULIC SYSTEMS.
Michael D. D'Agostino and Frederick J. Kuehne (Grumman Aircraft Engineering Corp., Bethpage, N.Y.).
IN: RADIOISOTOPES FOR AEROSPACE; PROCEEDINGS OF THE FIRST SYMPOSIUM ON RADIOISOTOPE APPLICATIONS IN AEROSPACE, DAYTON, OHIO, FEBRUARY 15-17, 1966. PART 1 - ADVANCES AND TECHNIQUES. [A67-12207 02-14]
Symposium sponsored by the U.S. Air Force, the U.S. Atomic Energy Commission, and the Instrument Society of America.
Edited by J. C. Dempsey and Paul Polishuk.
New York, Plenum Press, Division of Plenum Publishing Corp., 1966, p. 346-379.
Contract No. NOw-63-0708-c.

Discussion of the development of a simplified, inexpensive means of using neutron activation analysis to detect metallic deterioration products filtered out of hydraulic systems. The method involves activating the total residue collection of unknown residue with neutrons, measuring the induced gamma ray activity at preselected times, and recording the total counts in each of a few selected photopeaks. The initial activities of each of the desired radioisotopes are then computed using a simple "cookbook" procedure, and these initial activities are compared with the corresponding initial activities of simultaneously irradiated standards, the weights of which are accurately known. B.B.

A67-12229 #
THE "FEEL" OF ROTARY CONTROLS - FRICTION AND INERTIA.
William B. Knowles (Hughes Aircraft Co., Signal Processing and Display Laboratory, Culver City, Calif.) and Thomas B. Sheridan (Massachusetts Institute of Technology, Cambridge, Mass.).
Human Factors, vol. 8, June 1966, p. 209-215. 9 refs.

Study to determine the influence of friction and inertia levels on the "feel" of rotary controls. Detection thresholds for changes in friction and inertia were determined and found to be about 10 to 20% of the initial values. Preference ratings obtained for various combinations of friction and inertia increased as a function of inertia level and decreased as a function of friction level. Preferences for viscous friction were greater than for stick-slip friction. Psychophysical evaluations such as these are related to customer acceptance factors and provide a useful supplement to purely functional design criteria. (Author)

A67-12453 *
LUBRICANTS AND MECHANICAL COMPONENTS OF LUBRICATION SYSTEMS FOR SPACE ENVIRONMENT.
R. L. Johnson (NASA, Lewis Research Center, Lubrication Branch, Cleveland, Ohio) and D. H. Buckley (NASA, Lewis Research Center, Space Environment Lubrication Section, Cleveland, Ohio).
(American Society of Lubrication Engineers, Annual Meeting, 19th, Chicago, Ill., May 26-28, 1964, Paper.)
Lubrication Engineering, vol. 22, Oct. 1966, p. 408-414. 45 refs.

A67-12454
SURVEY OF AEROSPACE REQUIREMENTS FOR BEARINGS AND LUBRICANTS.

D. G. Flom (General Electric Co., Missile and Space Div., Space Sciences Laboratory, Philadelphia, Pa.).
(American Society of Lubrication Engineers, Annual Meeting, 19th, Chicago, Ill., May 26-28, 1964, Paper.)
Lubrication Engineering, vol. 22, Oct. 1966, p. 415-423. 24 refs.

Discussion of the unique requirements for bearings and lubricants used in aerospace applications. Space-associated natural environments that are investigated include low pressures, temperature extremes, meteoroid impact, electromagnetic and particulate radiation, and low gravitational forces. Vehicle and mission-related induced environments are considered, such as acceleration, shock, vibration loading, severe temperature extremes, and nuclear radiation. B.B.

A67-12499 #
FUNDAMENTAL RESEARCH ON GEAR LUBRICATION.
Tokio Sasaki, Kenjiro Okamura, and Tadataka Konishi (Kyoto University, Dept. of Precision Mechanics, Kyoto, Japan).
Kyoto University, Faculty of Engineering, Memoirs, vol. 18, July 1966, p. 277-317. 8 refs.

Investigation of the fundamental characteristics of gear lubrication and the formation of an oil film between mating gear teeth, with a consideration of the dynamic performance of the gear teeth. The fundamental lubrication characteristics were measured under various driving conditions by using roller and gear testing equipment, and the lubrication characteristics were classified into three types. The analysis of the dynamic phenomena caused by gear mating is of great significance. The transient characteristics of the oil film caused by the gear mesh were theoretically analyzed, and the performance of the film was experimentally measured. The dynamic lubrication theory was applied to the various actual gears, with a consideration of tooth deflection, and the variation in thickness of the oil film was measured throughout the overall range of a gear-tooth mesh by using special test gears. The principles of oil-film formation are discussed on the basis of the results obtained. W.A.E.

A67-12710 #
HIGHER MODES OF CRITICAL SPEED OF SHAFTS WITH ELASTIC BEARING MOMENTS.
Jaakko Wuolijoki and Seppo Väisänen (Teknillinen Korkeakoulu, Helsinki, Finland).
Acta Polytechnica Scandinavica, Mechanical Engineering Series, no. 26, 1966. 22 p.

Study of the second-order to fifth-order critical speeds of a bending homogeneous steel shaft with a nonnegligible mass, with allowance for the shear deformation and the inertia effect of the rotary motion in the deflection plane. It is assumed that an elastic clamping moment governed by a linear law is present at the supports and that it acts in accordance with a coefficient of end restraint which may have any arbitrary value. Formulas are derived which give the critical speed for a shaft mounted on two supports and for a cantilever shaft. Graphs containing auxiliary curves for determination of certain slenderness ratios of the shaft are included. W.A.E.

A67-13016
LUBRICANTS AND LUBRICANT TESTING FOR SUPERSONIC AIRCRAFT [SCHMIERSTOFFE FÜR ÜBERSCHALLFLUGZEUGE UND DEREN PRÜFUNG].
G. Spengler and E. K. Jantzen (Deutsche Versuchsanstalt für Luft- und Raumfahrt, Institut für Flugtreib- und Schmierstoffe, Munich, West Germany).
(Wissenschaftliche Gesellschaft für Luft- und Raumfahrt, Europäischer Luftfahrtkongress, 6th, Munich, West Germany, Sept. 1-4, 1965, Paper.)
IN: YEARBOOK 1965; WISSENSCHAFTLICHE GESELLSCHAFT FÜR LUFT- UND RAUMFAHRT, EUROPEAN AERONAUTICAL CONGRESS, 6TH, MUNICH, WEST GERMANY, SEPTEMBER 1-4, 1965, REPORTS [JAHRBUCH 1965; WISSENSCHAFTLICHE GESELLSCHAFT FÜR LUFT- UND RAUMFAHRT, EUROPÄISCHER LUFTFAHRTKONGRESS, 6TH, MUNICH, WEST GERMANY, SEPTEMBER 1-4, 1965, VORTRÄGE]. [A67-12965 03-02]
Edited by Hermann Blenk.
Braunschweig, West Germany, Friedrich Vieweg und Sohn GmbH, 1966, p. 419-423; Discussion, D. Genthe, G. Schneider, A. Dadieu, and P. Ruden, p. 423, 424. In German.

A67-13227 * #
EXPERIMENTS WITH HYDRODYNAMIC JOURNAL BEARINGS OF VARIOUS MATERIALS AND DESIGNS IN SODIUM AT TEMPERATURES TO 800°F.
Fredrick T. Schuller, William J. Anderson, and Zolton Nemeth (NASA, Lewis Research Center, Cleveland, Ohio).
Meeting on Development of Turbulent-Flow Bearings and Seals for Process-Fluid Lubricated Turbomachinery, Latham, N.Y., Nov. 1, 1966, Paper. 34 p. 9 refs.

Experiments were conducted with 1.5-in. diam hydrodynamic journal bearings in liquid sodium at 500 and 800°F, speeds to 12,000 rpm and unit loads to 31 psi. The stability characteristics of four different geometries and the wear and seizure properties of several material combinations were investigated. Tilting pad bearings were most stable. Combinations of a cobalt alloy with nickel alloys or with a titanium carbide cermet showed the best wear and seizure properties. (Author)

A67-13231 * #
FRICTION CHARACTERISTICS IN VACUUM OF SINGLE AND POLYCRYSTALLINE ALUMINUM OXIDE IN CONTACT WITH THEMSELVES AND WITH VARIOUS METALS.
Donald H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, Paper. 28 p. 34 refs.

Friction experiments were conducted in vacuum with outgassed surfaces. Experiments were made with single and polycrystalline Al_2O_3 samples sliding on themselves and in contact with metals at a sliding velocity of 0.013 cm/sec at loads to 1500 g, temperatures to 575°C and ambient pressures to 10^{-10} mm Hg. These studies were made with a hemispherical or spherical rider sliding on the flat of a rotating disk. The results of the investigation indicate that: (1) the friction characteristics of sapphire sliding on sapphire is highly anisotropic, (2) with metals sliding on sapphire, fracture occurs in the sapphire while with polycrystalline Al_2O_3 shear occurs in the metal, and (3) hexagonal metals exhibited lower friction coefficients than cubic metals in contact with polycrystalline Al_2O_3. (Author)

A67-13271 * #
THE INFLUENCE OF VARIOUS PHYSICAL PROPERTIES OF METALS ON THEIR FRICTION AND WEAR BEHAVIOR IN VACUUM.
Donald H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio).
American Society for Metals, American Society for Testing and Materials, and Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers, Metal Congress, Chicago, Ill., Oct. 30-Nov. 4, 1966, Paper. 26 p. 36 refs.

Friction and adhesion studies in vacuum indicate that very high coefficients of friction and adhesion as well as complete welding of many conventional metals and alloys will occur in the vacuum environment of space. Examination of the fundamental properties of metals reveals that many physical properties can markedly influence the friction, adhesion, wear and welding tendency of metals in vacuum. Such properties as mutual solubility, crystal structure, lattice parameters, atomic density and ordering of alloys are all found to have an influence on the observed friction behavior of metals, once surface oxides and contaminants are removed. The study examines single and polycrystalline materials, conventionally used bearing alloys, as well as high purity metals. The alloys include bearing steels as well as copper, cobalt, and titanium alloys. Metallic elements examined in single and polycrystalline form include iron, nickel, copper, cobalt, titanium, beryllium, zirconium, hafnium, tungsten, and the rare earth metals. (Author)

A67-13333
MOLECULAR PHYSICS OF BOUNDARY FRICTION.
A. S. Akhmatov.
(Translation of Molekuliarnaia Fizika Granichnogo Treniia, Moscow, Gosudarstvennoe Izdatel'stvo Fiziko-Matematicheskoi Literatury, 1963).
Jerusalem, Israel Program for Scientific Translations, Ltd.; New York, Daniel Davey and Co., Inc., 1966. 480 p.
$19.

A67-13749
ANGULAR CONTACT HYDROSTATIC BEARING FOR RADAR PEDESTALS.
G. M. Robinson and J. C. Spracklin (Radio Corporation of America, Moorestown, N.J.).
IN: DEEP SPACE AND MISSILE TRACKING ANTENNAS; AMERICAN SOCIETY OF MECHANICAL ENGINEERS, WINTER ANNUAL MEETING, AVIATION AND SPACE SYMPOSIUM, NEW YORK, N.Y., NOVEMBER 27-DECEMBER 1, 1966, PAPERS. [A67-13748 03-09]
New York, American Society of Mechanical Engineers, 1966, p. 1-14.

Description of the machine design, capillary control selection, hydraulic circuitry, and oil selection of two two-surface angular hydrostatic bearings used for the azimuth turntable of two radar antenna pedestals. The hydrostatic bearing is capable of providing high bearing stiffness without increasing turntable friction. The larger of the two bearings is analyzed, and a matrix-type solution is used to provide a closed solution for the dynamic response about each axis and the degree of cross coupling due to the angular surface of the bearing. M.M.

A67-13754 #
FRICTION AND ADHESION OF COPPER IN VACUUM.
R. D. Brown (Southwest Research Institute, San Antonio, Tex.) and R. A. Burton (Southwest Research Institute, Lubrication Research Section, San Antonio, Tex.).
American Society of Mechanical Engineers and American Society of Lubrication Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, Paper 66-Lub-3. 7 p. 18 refs.
Members, $0.75; nonmembers, $1.50.
Contract No. AF 33(615)-1310.

Friction and adhesion coefficients of copper on copper were measured in vacuum (5×10^{-10} to 4×10^{-7} torr) at temperatures ranging from -270 to 1000°F, and in controlled pressures of dry air ranging from 10^{-9} to 760 torr at 75°F. The effects of duration of exposure of surfaces to vacuum, and the effects of contact duration on adhesion were studied. Friction coefficients were very high (2.2 to over 16) and increased greatly with temperature; adhesion coefficients also increased with temperature, but at given temperatures, were about one-tenth the magnitudes of the friction coefficient. (Author)

A67-13755 #
AN EXPERIMENTAL STUDY OF ANNULAR FLOWS WITH APPLICATIONS IN TURBULENT FILM LUBRICATION.
R. A. Burton and H. J. Carper (Southwest Research Institute, San Antonio, Tex.).
American Society of Mechanical Engineers and American Society of Lubrication Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, Paper 66-Lub-14. 11 p. 13 refs.
Members, $0.75; nonmembers, $1.50.

Experiments are reported on turbulent flows in air, in a large-scale bearing model of 6-ft diam, 2-ft length, 0.54-in. film thickness. Simulation of tilted pads, short journal bearings, and stepped pads is described. Pressure distributions are reported along with velocity and turbulence-intensity profiles. Wall shear stress is computed from the velocity profile measurements. The variations of these factors are compared with available data for plane Couette flow, wall law flow, and pressure flow in pipes, and the relationships among these are discussed. In addition, large pressure jumps at discontinuities are reported, and are shown to provide a major influence on the overall pressure distributions. (Author)

A67-13759 #
EXTERNALLY PRESSURIZED BEARINGS AS SERVOMECHANISMS. I.
Donald F. Wilcock (Mechanical Technology, Inc., Latham, N.Y.).
American Society of Mechanical Engineers and American Society of Lubrication Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, Paper 66-Lub-7. 7 p.
Members, $0.75; nonmembers, $1.50.

Analysis of externally pressurized (EP) bearings in which the latter are treated as an hydraulic closed-loop servomechanism. The use of restrictor feed devices introduces an inner loop that reduces the gain. The time-dependent flow due to the change in volume with film thickness creates a "lead" break frequency favorable to stability. Fluid compressibility, on the other hand, leads to a "lag" break frequency which, if it approaches or becomes less than the "lead" frequency, results in bearing instability. Analysis by transfer function furnishes fresh insight into EP bearing behavior. M.F.

A67-13760 * #
ON ASYMPTOTIC ANALYSIS OF GASEOUS SQUEEZE-FILM BEARINGS.
C. H. T. Pan (Mechanical Technology, Inc., Latham, N.Y.).
American Society of Mechanical Engineers and American Society of Lubrication Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, Paper 66-Lub-11. 9 p. 5 refs.
Contract No. NAS 8-11678.

Analysis of the high-frequency gaseous squeeze-film bearing by considering the internal region and edge regions separately. The internal region obeys the asymptotic equation which is formally similar to the equation for the time-dependent self-acting gas bearing; consequently its solution can be obtained by various methods. In an edge region, the governing equation is a form of the diffusion equation with relatively simple coefficients. Solution of the asymptotic equation for a given bearing geometry is quite straightforward, as exemplified by such a solution for the conical squeeze-film bearing. In this example it is shown that load capacity to resist axial, radial, and angular displacements can be generated by a periodic axial motion of the bearing surface. F.R.L.

A67-13761 #
A THEORY FOR TURBULENT FLUID FILMS AND ITS APPLICATION TO BEARINGS.
H. G. Elrod, Jr. (Columbia University, New York, N.Y.) and C. W. Ng (Illinois Institute of Technology, Research Institute, Chicago, Ill.).
American Society of Mechanical Engineers and American Society of Lubrication Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, Paper 66-Lub-12. 17 p. 15 refs.
Members, $0.75; nonmembers, $1.50.
AEC Contract No. AT (30-1)-3363.

Derivation of a new turbulent lubrication analysis which takes into account certain well-established facts concerning turbulent shear flow. Consistent with lubrication film theory, the nature of the local flow is taken to depend only on local film thickness, surface velocity, and pressure gradients. An eddy diffusivity treatment is used which incorporates the "law of wall" with the use of local shear stress. Stress-reversal phenomena are accomodated, and isotropy of the turbulent exchange mechanism in the plane of the film is assured. Coefficients are developed for use in the generalized Reynolds lubrication equation, and computation procedures for the static and dynamic characteristics of turbulent, self-acting bearings are presented. The nonlinear effects due to the coupling of the shear-induced flows and the flows due to the circumferential and axial pressure gradients are fully considered. It is believed that the analysis is directly applicable to turbulent, externally pressurized, and hybrid bearings. F.R.L.

A67-13765 #
THERMAL DISTORTION OF SPIRAL-GROOVED GAS-LUBRICATED THRUST BEARING DUE TO SELF-HEATING.

C. H. T. Pan and B. Sternlicht (Mechanical Technology, Inc., Latham, N.Y.).
American Society of Mechanical Engineers and American Society of Lubrication Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, Paper 66-Lub-10. 6 p. 7 refs.
Members, $0.75; nonmembers, $1.50.
Navy-supported research.

The effects of thermal distortion due to viscous heating in the fluid film on the performance of a spiral-grooved, gas-lubricated thrust bearing are analyzed. A numerical example shows that considerable loss of load capacity is possible for bearings made of common structural materials. A simple criterion has been developed to check the importance of this type of thermal distortion. (Author)

A67-14285 #
METHOD OF REDUCING THE RESPONSE OF A DIRECTIONAL GYRO TO RANDOM DISTURBANCES [OB ODNOM METODE UMEN'-SHENIIA REAKTSII GIROSKOPA NAPRAVLENIIA NA SLUCHAINYE VOZMUSHCHENIIA].
E. G. Shmuilovich (Leningradskii Institut Aviatsionnogo Priborostroeniia, Leningrad, USSR).
Priborostroenie, vol. 9, no. 5, 1966, p. 116-120. In Russian.

Discussion of the problem of reducing the effect of friction in the bearings of a directional gyro, by providing different rotation in bearings of the horizontal axis, on the accuracy of the device in conditions of irregular rocking at sea. It is shown that the use of different-rotation bearings, besides its primary purpose of decreasing bearing friction, is also an efficient means of reducing gyro error resulting from random disturbances of the base. V.P.

A67-14412 #
TRANSDUCERS FOR NONELECTRICAL QUANTITIES BASED ON SERVOMECHANICAL PRINCIPLES - THEIR PROPERTIES AND TESTING [SNÍMAČE NEELEKTRICKÝCH VELIČIN, ZALOZENÉ NA SERVOMECHANICKÉM PRINCIPU, JEJICH VLASTNOSTI A ZKOUŠENÍ].
Alois Šťastný.
Zpravodaj VZLÚ, no. 2, 1966, p. 33-40. 6 refs. In Czech.

Discussion of the possibilities of investigating the static and dynamic properties of servomechanical transducers for nonelectrical signals with the help of electrical signals. The analysis shows that tests with current signals are more suitable for determining the static properties while tests with voltage signals are more appropriate for determining the dynamic properties. The properties of the sensing and compensating elements are briefly discussed. It is found that the effect of Coulomb friction can be considerably decreased by the proper application of an electrical signal to the transducer. S.Z.

A67-14432
DAMPING IN EXTERNALLY PRESSURISED GAS BEARING JOURNALS.
N. Tully (Portsmouth College of Technology, Dept. of Mechanical Engineering, Portsmouth, England).
The Engineer, vol. 222, Nov. 25, 1966, p. 794-797. 7 refs.

Description of simple analytical work and experimental evidence on vibrational damping of annular externally pressurized orifice journal bearings undergoing free vibrations both with and without shaft rotation. It was found possible to predict well the damping to free vibrations of a stationary shaft supported in annular orifice bearings by a simple superposition of aerodynamic damping and aerostatic stiffness. M.M.

A67-14461 #
MAGNETOHYDRODYNAMIC LUBRICATION FLOW BETWEEN PARALLEL PLATES.
E. Roland Maki, Dennis C. Kuzma (General Motors Corp., Research Laboratories, Warren, Mich.), and Russell J. Donnelly (Chicago, University, Chicago, Ill.).
Journal of Fluid Mechanics, vol. 26, Nov. 1966, p. 537-543.
USAF-NSF-ARPA-supported research.

The magnetohydrodynamic lubrication flow in an externally pressurized thrust bearing is investigated both theoretically and experimentally. The ordinary magnetohydrodynamic lubrication theory for this bearing is extended to include fluid inertia effects. Very good agreement is obtained between theory and experiment. (Author)

A67-14576 #
CORROSION PROTECTION FOR MODERN AIRCRAFT [KORROSIONSSCHUTZ MODERNER FLUGZEUGE].
Gerhard Hoffmann (Hamburger Flugzeugbau GmbH, Hamburg, West Germany).
Wissenschaftliche Gesellschaft für Luft- und Raumfahrt and Deutsche Gesellschaft für Raketentechnik und Raumfahrt, Jahrestagung 1966, Bad Godesberg, West Germany, Oct. 4-8, 1966, Paper. 11 p. In German.

Discussion of the causes and types of corrosion sustained by modern aircraft, mentioning ablation, pitting, and fatigue effects. Eloxation is assessed as an anticorrosion technique and its negative effect on the endurance of aircraft structural parts and material is indicated. Electrophoretic deposition of multilayer synthetic resin coatings on aluminum and aluminum alloy surfaces is proposed as a technique to combat corrosion more effectively and without affecting endurance. Laboratory tests of this method yielded favorable results. V.Z.

A67-14602
THE STRESS CORROSION THREAT.
John A. King.
Space/Aeronautics, vol. 46, Oct. 1966, p. 61-67.

Discussion of the uncertainties underlying the basic mechanisms of stress corrosion in titanium. The following ways of hedging against it are reviewed: surface treatment, reduction of design stress, environmental control, and especially alloy modification. The primary concern of designers regarding stress corrosion is the cooperative effect of two characteristics which distinguish the phenomenon from other causes of material failure: (1) materials which are stress-corrodable in a specific environment tend to fail under tensile stress which is often below nominal design loading, and (2) the corrosion function takes place in relatively mild environments, often with little evidence. S.Z.

A67-14707
PROPERTIES AND POTENTIALS OF HEAVY-METAL-DERIVATIVE SOLID LUBRICANTS.
Peter M. Magie (Bemol, Inc., Newton, Mass.).
(American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 2B3.)
Machine Design, vol. 38, Dec. 8, 1966, p. 203, 206, 208, 210.

A67-14804 #
CAUSES OF STRESS-CORROSION CRACKING.
Walter K. Boyd (Battelle Memorial Institute, Columbus, Ohio).
Battelle Technical Review, vol. 15, Nov. 1966, p. 5-10. 16 refs.

Evaluation of mechanical, electrochemical, and surface-energy theories of causation - as well as the roles of hydrogen and other factors - in stress-corrosion cracking. It is noted that it is unlikely that stress-corrosion cracking occurs by mechanical means as the result of high stress at the base of a pit or other stress raiser. On the other hand, there is strong evidence to support electrochemical initiation and propagation. In fact, stress-corrosion cracking may not be true cracking in the sense of brittle cleavage of the wall of the crack. M.M.

A67-14995
REVIEW OF THE INFLUENCE OF SPACE ENVIRONMENT UPON VEHICLE COMPONENTS.

Ronald Smelt (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Space Programs Div., Sunnyvale, Calif.).
IN: THE FLUID DYNAMIC ASPECTS OF SPACE FLIGHT; PROCEEDINGS OF THE NATO-AGARD SPECIALISTS' MEETING, MARSEILLE, FRANCE, APRIL 20-24, 1964. VOLUME 1. [A67-14987 04-12]
Meeting sponsored by the Fluid Dynamics Panel of AGARD.
New York, Gordon and Breach, Science Publishers, Inc. (AGARDograph 87. Volume 1), 1966, p. 141-165. 18 refs.

The paper examines environmental problems encountered in space vehicles. Much of the information has been obtained by practical experience of operations of Agena satellites, supported by laboratory work in specific areas. Outgassing in high vacuum, deterioration of materials by evaporation, and changes in mechanical and electrical properties of plastics are covered. Work has also concentrated on the problem of lubrication of bearing surfaces in space over long periods, arising from the evaporation of conventional lubricants. Vehicle problems presented by the multiple sources of space radiation are also reviewed, with emphasis on the resulting deterioration of surface properties. Examples are the changes in emissivity and absorptivity of temperature-controlling surfaces and the critical problem of deterioration of the performance characteristics of power-generating solar cells, particularly when exposed to Van Allen radiation. There is also some experience, from satellite flights, of the hazards presented by high-energy radiation from solar flares and its influence on internal components of space vehicles. Another area of potential hazard, from encounters with meteorites, is discussed, and experimental programs to evaluate possible damage are reviewed. (Author)

A67-15346 #
STATOR WHIRL WITH ROTORS IN BEARING CLEARANCE.
W. F. Ehrich and J. J. O'Connor (General Electric Co., Flight Propulsion Div., Lynn, Mass.).
American Society of Mechanical Engineers, Winter Annual Meeting and Energy Systems Exposition, New York, N.Y., Nov. 27-Dec. 1, 1966, Paper 66-WA/MD-8. 9 p.
Members, $0.75; nonmembers, $1.50.

Identification of a new class of vibrational behavior and quantification for rotors operating in bearing clearance. Most significant of these phenomena is stator whirl, wherein large stator amplitudes may be experienced at supercritical speeds. In addition, certain new jump phenomena and hysteresis phenomena are noted and described. Structural damping and bearing contact friction do not make a fundamental change in the general nature of the observed phenomena. S.Z.

A67-15349 #
LUBRICATION REVIEW - A DIGEST OF THE LITERATURE FOR 1965.
W. A. Harris (SKF Industries, Inc., King of Prussia, Pa.), H. F. Garry (Climax Molybdenum Company of Michigan, Ann Arbor, Mich.), C. N. Rowe (Socony Mobil Oil Co., Inc., Princeton, N.J.), M. J. Wojtowicz (H. A. Montgomery Co., Detroit, Mich.), P. F. Brown (United Aircraft Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.), J. H. Rumbarger, O. Decker (Franklin Institute, Research Laboratories, Philadelphia, Pa.), V. Hopkins, and R. Schroeder (Midwest Research Institute, Kansas City, Mo.).
American Society of Mechanical Engineers, Winter Annual Meeting and Energy Systems Exposition, New York, N.Y., Nov. 27-Dec. 1, 1966, Paper 66-WA/LUB-8. 30 p. 397 refs.
Members, $0.75; nonmembers, $1.50.

Review of the literature published in 1965 on lubrication and bearings. Material reviewed is subdivided into seven groups - friction and wear, boundary lubrication, metalworking lubrication, gear and spline lubrication, rolling element bearings, lubricant development, and fluid film lubrication and bearings. F.R.L.

A67-15618
CORROSION OF BERYLLIUM BY SALT WATER.
W. J. Prochko (USAF, Systems Command, Foreign Technology Div., Wright-Patterson AFB, Ohio), J. R. Myers (USAF, Corrosion Research Laboratory; USAF, Air University, Institute of Technology, Wright-Patterson AFB, Ohio), and R. K. Saxer (U.S. Air Force Academy, Colorado Springs, Colo.).
Materials Protection, vol. 5, Dec. 1966, p. 39-42. 6 refs.

Investigation of the corrosive effect of chlorides in aqueous environments on pickled and anodized specimens of sheet beryllium. Experiments in such environments as distilled water, synthetic sea water, natural sea water, 3% NaCl solution, and 3.5% NaCl solution are described. It is concluded that unprotected beryllium sheet cannot be used where it will be totally immersed in aqueous chloride environments; it can be used only where pitting attack can be tolerated. The application of stress to both anodized and pickled beryllium sheet exposed to natural sea water further restricts its use because of stress-corrosion failure. B.B.

A67-16065 #
FRICTION, LUBRICATION AND WEAR - A SURVEY OF WORK DURING THE LAST DECADE.
F. P. Bowden and D. Tabor (Cambridge, University, Cavendish Laboratory, Cambridge, England).
British Journal of Applied Physics, vol. 17, Dec. 1966, p. 1521-1544. 161 refs.

The article describes the progress that has been made during the last decade in our understanding of the processes involved in friction, lubrication and wear. It does not pretend to be an encyclopedic survey, but instead summarizes work that seems to be of greatest significance. The first section deals primarily with the broader issues underlying the friction of unlubricated surfaces. The second section deals with specific items of research, many of which have opened up new lines of attack. The third, for completeness, deals with lubrication and wear. (Author)

A67-16273 #
ON THE POSSIBILITIES OF MAGNETOGASODYNAMIC LUBRICATION.
V. N. Constantinescu (Academia Română, Institutul de Mecanica Fluidelor, Laboratorul de Lubrefianţi Gazoşi, Bucharest, Rumania).
American Society of Mechanical Engineers, Paper no. 66-LUB-C, 1966. 9 p. 19 refs.

The problem of gas film lubrication is considered, by assuming the existence of an electrical conductibility for the gas and that the motion is subjected to the influence of external electromagnetic fields. The MGD-lubrication equations are written under a general form. Several external electromagnetic conditions are considered, divided in two classes: (1) transversal magnetic field, and (2) tangential magnetic field combined with transversal electrical field. For each case the pressure differential equation is deduced and the possibilities of obtaining approximate solutions are briefly discussed, as well as the existence of some limiting solutions. Finally, the possibilities of improving the operation of both self-acting and externally pressurized gas bearings are pointed out. (Author)

A67-16275 #
MAGNETOHYDRODYNAMIC EFFECTS IN COMPOSITE BEARINGS.
J. Prakash (Institute of Higher Technology, Dept. of Mathematics, Kanpur, India).
American Society of Mechanical Engineers, Paper no. 66-LUB-B, 1966. 6 p. 6 refs.

Theoretical analysis of a composite slider bearing using an electrically conducting lubricant such as a liquid metal in the presence of a magnetic field applied perpendicular to the bearing surfaces. Two solutions are presented for large and small values of Hartmann number. It is found that for large Hartmann number significant increase in load capacity can be obtained even under open circuit conditions. M.F.

A67-16932 * #
LUBRICATION AND BEARING PROBLEMS IN THE VACUUM OF SPACE.
Edmond E. Bisson (NASA, Lewis Research Center, Cleveland, Ohio).
Groupement pour l'Avancement de la Mécanique Industrielle, Journées d'Etude du Frottement et de l'Usure, Paris, France, Dec. 5, 6, 1966, Paper. 32 p. 25 refs. Translation.

A67-16981

Discussion of various lubrication and bearing problems of the space age, their relative importance, and pertinent research in the various fields. It is pointed out that actual conditions of space are not precisely known and that duplication of conditions is therefore difficult, but simulation is possible. Low evaporation rates are obtained with some metals, some lubricating compounds, and teflon. In friction and wear experiments with various lubricant coatings in vacuum, MoS_2 and other films appear promising. Experiments with instrument-size bearings in vacuum show good results with silicones and silicone greases as the lubricant. Other experiments have been done with self-lubricating cages or retainers, and reasonably successful operation has been achieved. Successful operation in space of a mechanism was obtained on an actual satellite. Vacuum friction studies have been proved useful in exploring effects normally hidden because of the usual presence of oxides in air. M.M.

A67-16981

MAGNETOHYDRODYNAMIC PIVOTED SLIDER BEARING WITH A CONVEX PAD SURFACE.

Jagdish Prakash (Institute of Higher Technology, Dept. of Mathematics, Kanpur, India).

Japanese Journal of Applied Physics, vol. 5, Nov. 1966, p. 1094-1099.

A theoretical analysis is presented for a pivoted slider bearing in the presence of an external magnetic field applied parallel to the bearing surface and perpendicular to the direction of motion. The analysis takes into account the pad surface curvature, which is usually neglected. The effect of this curvature is shown in a family of curves. (Author)

A67-17034

MICROSTRUCTURE OF "MOLECULAR" CERMETS [O MIKROSTRUKTURE "MOLEKULIARNYKH" KERMETOV].

P. P. Budnikov and N. V. Shishkov (Moskovskii Khimiko-Tekhnologicheskii Institut, Moscow, USSR).

Poroshkovaia Metallurgiia, vol. 6, Nov. 1966, p. 62-65. 6 refs. In Russian.

Preparation of two-component cermets by reduction with hydrogen and sintering of zirconium molybdate, calcium molybdate, and nickel chromate. Zr-Mo, Ca-Mo, and Ni-Cr cermets with a fine structure and highly homogeneous phase distribution are obtained. Technical defects affecting the structure of these products are identified.

V.Z.

A67-17795

MONOCRYSTALS IN MECHANICAL TECHNOLOGY.

John J. Gilman (Illinois, University, Urbana, Ill.).

ASM Transactions Quarterly, vol. 59, Dec. 1966, p. 597-629. 62 refs.

Discussion of the use of individual crystals for stress-resisting devices - e.g., turbine blades for advanced jet engines. Such crystals provide high structural reliability coupled with maximum possible strength. They permit hotter engine temperatures, greater pressures, stronger centrifugal forces, greater impact resistance, higher magnetic fields, and increased resistance to radiation damage. The factors responsible for the strength of crystals are considered, as well as the elastic stiffnesses of metals and other crystals. The influence of internal boundaries on strength is examined extensively. The advantages of monocrystals for design and fabrication are discussed, and some technological opportunities are outlined.

F.R.L.

A67-17951

THE ROLE OF IMPURITIES IN REACTIONS BETWEEN LIQUID ALLOYS AND SOLID METALS UNDERGOING DEFORMATION.

M. I. Chaevskii (Akademiia Nauk Ukrainskoi SSR, Fiziko-Mekhanicheskii Institut, Lvov, Ukrainian SSR).

(Fiziko-Khimicheskaia Mekhanika Materialov, vol. 1, May-June 1965, p. 344-349.)
Soviet Materials Science, vol. 1, May-June 1965, p. 235-238. 14 refs. Translation.

Examination of the role of impurities (primarily oxygen) in reactions between liquid alloys and solid metals undergoing deformation. Plots are given of (1) the breaking stress of Armco iron as a function of time-to-rupture for notched strip specimens tested at 1073°K, (2) fatigue curves of normalized specimens of Mark 50 steel, (3) the temperature dependence of the free energy of formation of oxides by six reactions, and (4) the tensile breaking stress of notched specimens of a carbon steel (water-quenched from 1073°K and tempered at 773°K) at 673°K as a function of time-to-rupture. D.H.

A67-18060

PRESSURE DISTRIBUTION IN EXTERNALLY PRESSURIZED BEARINGS.

J. Prakash (Institute of Higher Technology, Dept. of Mathematics, Kanpur, India) and H. C. Agrawal (Institute of Higher Technology, Dept. of Mechanical Engineering, Kanpur, India).

International Journal of Mechanical Sciences, vol. 9, Jan. 1967, p. 53-56.

Derivation of a modified solution for pressure distribution in externally pressurized bearings. Comparison is made with an earlier theory proposed by Sasaki and Mori. Only the case of a purely hydrostatic bearing with constant film thickness is considered; the effect of sliding speed and film thickness variations can be easily incorporated in a manner similar to that of Sasaki and Mori. B.B.

A67-18236

INFLUENCE OF HEAT TREATMENT ON THE STRUCTURE AND PROPERTIES OF VT1 TITANIUM AND THE OT4 ALLOY.

A. P. Akshentseva and G. N. Shumratova.

(Metallovedenie i Termicheskaia Obrabotka Metallov, Feb. 1966, p. 51-55.)
Metal Science and Heat Treatment, Jan.-Feb. 1966, p. 147, 148. Translation.

A67-18837

ROLLING BEARING ANALYSIS.

T. A. Harris (SFK Industries, Inc., Engineering and Research Center, King of Prussia, Pa.).

New York, John Wiley and Sons, Inc., 1966. 481 p. $27.50.

This is a test designed to present a unified up-to-date approach to the analysis of rolling-bearing performance. The format is aimed at developing a basic understanding of rolling bearing operation. Initially, the simplest elements of rolling bearings, such as basic bearing types, geometry, loading of single balls and rollers, and contact stresses and deformations are discussed. The complex analysis of load distribution among the rolling elements, speeds and velocities, elastohydrodynamic lubrication, statistics of bearing endurance, fatigue life, friction, and temperature is then considered. Each new topic depends almost entirely on the preceding discussions. To amplify these discussions, numerical examples are given, in which a single bearing of each type is examined. The material covered spans the disciplines of geometry, mechanical elasticity, dynamics, statics, hydrodynamics, statistics, and heat transfer.

S.Z.

A67-19170

EFFECT OF LOADING RATES ON POLYMER WEAR [VLIIANIE SKOROSTEI NAGRUZHENIIA NA IZNOS POLIMEROV].

G. A. Gorokhovskii, G. P. But, and L. I. Bezruk (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukrainian SSR).

Mekhanika Polimerov, no. 6, 1966, p. 862-866. In Russian.

Experimental study of wear effects in polymers coupled with metals under various frictional loads. Used in flexible polymer-metal joints were polytetrafluoroethylene, low-pressure polyethylene polycaprolactam, and phenol-formaldehyde resin rings in frictional contact with metal surfaces. The wear was investigated for a 1200 m surface run with and without lubrication at sliding rates of 0.053, 0.144, and 0.420 m/sec with the entire nominal load of 16 daN/cm^2 applied abruptly, or gradually at a rate of 0.22 daN/cm^2-sec. Wear effects are found to be lower under gradually applied loads.

V.Z.

A67-19403
FRICTIONLESS BEARING FOR BALLOON.
K. R. Park, L. Paquet, and A. K. Laflamme (Canadian Armament Research and Development Establishment, Valcartier, Quebec, Canada).
Applied Optics, vol. 6, Feb. 1967, p. 346.

Description of a novel device for azimuth stabilization of balloons floating at ceiling which acts as a frinctionless bearing to decouple the gondola from the balloon. It has been used in studies of the day, twilight, and night airglow where it has successfully controlled the azimuth of a 260-kg gondola to within 5°, with a power consumption of 7 watts. B. B.

A67-19466
CORROSION STUDIES OF TUNGSTEN, MOLYBDENUM, AND RHENIUM IN LITHIUM.
J. A. De Mastry (Battelle Memorial Institute, Columbus, Ohio).
(American Nuclear Society, Winter Meeting, Symposium on Materials for Large Space Power Systems, Washington, D.C., Nov. 15-18, 1965, Paper.)
Nuclear Applications, vol. 3, Feb. 1967, p. 127-134. 11 refs.

The compatibility of tungsten, W-0.9 wt% Cb, W-10 wt% Re, W-25 wt% Re, TZM (Mo-0.5 wt% Ti-0.08 wt% Zr), Mo-50 wt% Re, and rhenium in static lithium was determined. Exposures were at 2500, 2800, and 3000°F for periods of 100 and 1000 hr. Exposures were conducted in TZM containers for all alloys tested. The results obtained must be viewed in light of the dissimilar capsule employed. The tungsten-base materials were not attacked by lithium after 100- or 1000-hr exposure at 2500°F. At 2800°F, all of the tungsten-base materials exhibited varying degrees of surface dissolution and grain-boundary penetration. TZM and Mo-50 wt% Re alloys were resistant to attack by lithium at up to 3000°F for 100- and 1000-hr exposure. Unalloyed rhenium underwent dissimilar metal interaction while immersed in lithium in TZM test capsules for 1000 hr at 2500°F and 100 hr at 3000°F. Molybdenum was transferred from the TZM corrosion capsule to the rhenium where alloying occurred. (Author)

A67-20087
AIRCRAFT EXFOLIATION CORROSION - METHODS FOR PREVENTION IN FASTENER HOLES.
Robert N. Miller (Lockheed Aircraft Corp., Lockheed-Georgia Co., Research Laboratory, Marietta, Ga.).
Materials Protection, vol. 6, Feb. 1967, p. 55-58.

Discussion of the problem of exfoliation corrosion of aircraft fasteners and fastener holes. Tests with protective coatings and inhibitors are described, and the performances of precoated fasteners are outlined. B. B.

A67-20210 #
ON THE MAGNETOGASODYNAMIC LUBRICATION.
V. N. Constantinescu (Academia Română, Institutul de Mecanica Fluidelor, Bucharest, Rumania).
Revue Roumaine des Sciences Techniques, Série de Mécanique Appliquée, vol. 11, no. 4, 1966, p. 925-951. 16 refs.

The motion of a gas in thin layers is studied by assuming the existence of an electrical conductibility for the gas and considering that the motion is influenced by external electromagnetic fields. Starting from the general equations of the magnetogasodynamics and performing the simplifications customary for the current case of gas lubrication, the motion equations in the lubricating film are deduced in the conditions of the existence of any one electric and magnetic fields. Further a series of particular electromagnetic fields are considered by taking into account the practical possibilities of construction. Two interesting cases result: (1) a magnetic field transversal with respect to the lubricated insulated surfaces, (2) the existence of a tangential magnetic field (the electrical current normal to the surfaces which perform the role of electrodes). For the two mentioned cases the motion equations are integrated, the velocity distributions being thus obtained. Then, by means of the continuity equation, the pressure differential equations are written. The last part of the paper contains a qualitative study of the pressure equation in order to put into evidence the peculiarities and the advantages of the magnetogasodynamic lubrication. (Author)

A67-20250
ELECTRON FRACTOGRAPHY PINPOINTS CAUSE OF FATIGUE FRACTURE.
Edward A. Lauchner and Robert E. Herfert (Northrop Corp., Northrop Norair, Hawthorne, Calif.).
Metal Progress, vol. 91, Feb. 1967, p. 79, 80.

Use of electron fractographic analysis to determine the exact cause of failure during a fatigue test of an aluminum component machined from a 7079-T6 forging. Since the failure analysis proved that a crack, originally thought to be a fatigue failure, was actually a stress-corrosion crack, the importance of the electron microscope in performing detailed fractographic analysis becomes obvious. By resolving the characteristic fracture mode, the exact mode of failure can be more accurately determined. M. F.

A67-20307
NATURE AND MECHANISM OF STRENGTH OF MATERIALS [ÜBER DAS WESEN UND DEN MECHANISMUS DER FESTIGKEIT].
Arnold Tross.
Munich, Arnold Tross, 1966. 206 p. In German.
$8.75.

This book is a study in the submicro-, micro-, and macroscopic ranges, using a new energy-based hypothesis of flow and fracture to explain the most important strength, friction, and wear phenomena. A hypothesis is proposed which relates the concepts of energy density, plastic deformation, and friction heat in a new way. This hypothesis is further developed and extended to such strength phenomena as tensile strength, yield point, creep limit, and breaking strength. An attempt is made to develop a new strength hypothesis which takes into account atomic and crystallographic patterns in such a way as to relate these patterns to known strength phenomena. This hypothesis is used to interpret strength phenomena during and after a continuous stress. Various types of fracture are considered in the light of this hypothesis, as well as the mechanisms of friction and wear. A. B. K.

A67-20361
ASPECTS OF LUBRICATION AFFECTING LIFE OF ROLLING BEARINGS.
J. C. Bell and J. W. Kannel (Battelle Memorial Institute, Columbus, Ohio).
(American Society for Metals, 1966 National Metal Exposition and Congress, Chicago, Ill., Oct. 31-Nov. 3, 1966, Paper.)
Metals Engineering Quarterly, vol. 7, Feb. 1967, p. 28-35.
26 refs.
USAF-supported research.

Discussion of the forces which may act on the surfaces of roller bearings from the standpoint of procedures for identifying the influence of the lubricant to predict bearing life. Normal pressures acting in typical cases of rolling contact were measured using an electrical pressure transducer, and they agree reasonably well with theoretical pressure distributions. From the pressure measurement, subsurface stress distributions were calculated. These subsurface stresses differ somewhat according to the lubricant, but larger differences would appear to be needed to explain observed differences in bearing life. Film-thickness theory and measurements are briefly reviewed to project the circumstances under which the surface asperities might clash and induce an alternate regime of bearing failure. M. M.

A67-20597
QUANTITATIVE EVALUATION OF THE LIFE OF METAL-METAL/POLYMER COMPOSITE FRICTION PAIRS.
G. N. Dmitriuk, G. A. Gorokhovskii, and G. P. But (Kievskii Institut Grazhdanskogo Vozdushnogo Flota, Kiev, Ukrainian SSR).
(Fiziko-Khimicheskaia Mekhanika Materialov, vol. 1, Sept.-Oct. 1965, p. 516-521.)
Soviet Materials Science, vol. 1, Sept.-Oct. 1965, p. 358-361. 6 refs.
Translation.

Study of (1) the wear of a metal/polymer composite with the optimum polymer content and (2) the wear of a steel shaft operating in combination with the composite, as a function of time and operat-

ing conditions. The process is examined in both its initial stages and under steady-state conditions, polytetrafluoroethylene being used as the experimental polymer material. Due account is taken of the qualitative and quantitative laws governing the phenomena occurring at the friction interface. B. B.

A67-20598

FATIGUE STRENGTH AND ENDURANCE LIMIT OF ALUMINUM ALLOYS IN CORROSIVE MEDIA.

A. V. Karlashov, A. D. Gnatiuk, and V. P. Tokarev (Kievskii Institut Grazhdanskogo Vozdushnogo Flota, Kiev, Ukrainian SSR).

(Fiziko-Khimicheskaia Mekhanika Materialov, vol. 1, Sept.-Oct. 1965, p. 542-547.)
Soviet Materials Science, vol. 1, Sept.-Oct. 1965, p. 376-379. Translation.

Investigation of the effects of some corrosive media on the fatigue properties of three aluminum alloys used in the aircraft industry. The composition and mechanical properties of these alloys are tabulated. The conventional fatigue limits ($N = 5 \times 10^6$ cycles or 420 hr) of V92, D16ATV, and D16AT alloys, calculated for a fracture probability of 50 and 0.5%, are found to be reduced under the influence of a 3% NaCl solution by 36 and 40%, respectively. The corresponding reduction (calculated for a fracture probability of 0.5%), under the influence of water, amounts to 16 to 20% in the case of D16AT and D16ATV alloys. B. B.

A67-20599

A STUDY OF THE PROPERTIES OF ANTIFRICTION NICKEL-GRAPHITE COMPOSITES.

I. M. Fedorchenko, V. Ia. Bulanov, and G. F. Makshantsev (Akademiia Nauk Ukrainskoi SSR, Institut Problem Materialovedeniia, Kiev, Ukrainian SSR; Kuibyshevskii Politekhnicheskii Institut, Orenburg, USSR).

(Fiziko-Khimicheskaia Mekhanika Materialov, vol. 1, Sept.-Oct. 1965, p. 571-576.)
Soviet Materials Science, vol. 1, Sept.-Oct. 1965, p. 395-398. 7 refs. Translation.

Examination of the properties and methods of preparation of nickel-graphite composites. The experimental materials were fabricated from grade NP nickel powder, grade EUT-1 graphite powder and silico-calcium powder. Additions of calcium silicide to a nickel-graphite powder mixture is found to prevent the "sweating" of molten metal during sintering and to make it possible to obtain composites in which free graphite is uniformly distributed in a nickel-plated matrix. B. B.

A67-20840

DAMAGE PRODUCED BY A LASER BEAM IN A TRANSPARENT DIELECTRIC.

B. M. Ashkinadze, V. I. Vladimirov, V. A. Likhachev, S. M. Ryvkin, V. M. Salmanov, and I. D. Iaroshetskii (Akademiia Nauk SSSR, Fiziko-Tekhnicheskii Institut, Leningrad, USSR).

(Akademiia Nauk SSSR, Doklady, vol. 169, Aug. 11, 1966, p. 1041-1043.)
Soviet Physics - Doklady, vol. 11, Feb. 1967, p. 703-705. Translation.

A67-20917 #

THE RAYLEIGH STEP BEARING APPLIED TO A GAS-LUBRICATED JOURNAL OF FINITE LENGTH.

F. R. Archibald and B. J. Hamrock (Northrop Corp., Northrop Nortronics, Norwood, Mass.).

(American Society of Mechanical Engineers, Winter Annual Meeting, Chicago, Ill., Nov. 7-11, 1965, Paper 65-WA/Lub-2.)
ASME, Transactions, Series F - Journal of Lubrication Technology, vol. 89, Jan. 1967, p. 38-46. 7 refs.

A linearization method is employed on the Reynolds equation to obtain the load and friction torque of a Rayleigh step-film scheme applied to a journal bearing of finite length. The analysis is broken into two parts - the stepped and ridge regions. The film thickness is considered constant in each region, thereby simplifying the linearized Reynolds equation. In addition to the usual plain-bearing parameters (the compressibility number, eccentricity ratio, and length-to-diameter ratio), the load and friction force of a stepped bearing depend on the ratio of the stepped clearance to ridge clearance, the ratio of the width of ridge to the width of the pad, and the number of pads. The solution for the load and friction force for a single pad is obtained in the form of a highly convergent series. A number of equal pads are disposed around a journal and the total bearing load is computed for various eccentricities. Computation from the infinite series is lengthy and a digital computer was used in order to carry out the calculational work. This enabled optima to be selected for each system composed of different numbers of pads. The friction torque and hence the bearing power loss were computed for every case. (Author)

A67-21034

SNAP 8 REACTOR BEARING DEVELOPMENT.

L. G. Kellogg and W. G. Dewart (North American Aviation, Inc., Atomics International Div., Development and Product Operations Div., Canoga Park, Calif.).

(American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 7A1.)
ASLE Transactions, vol. 9, Oct. 1966, p. 325-334; Discussion, R. L. Johnson (NASA, Lewis Research Center, Cleveland, Ohio), p. 334; Author's Closure, p. 334, 335. 9 refs.
AEC Contract No. AT (11-1)-GEN-8.

A67-21035 *

SELF-LUBRICATING COMPOSITES OF POROUS NICKEL AND NICKEL-CHROMIUM ALLOY IMPREGNATED WITH BARIUM FLUORIDE-CALCIUM FLUORIDE EUTECTIC.

Harold E. Sliney (NASA, Lewis Research Center, Cleveland, Ohio).

(American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM IC2.)
ASLE Transactions, vol. 9, Oct. 1966, p. 336-345; Discussion, J. VanWyk (Boeing Co., Seattle, Wash.), M. J. Devine (U.S. Naval Air Engineering Center, Aeronautical Materials Laboratory, Philadelphia, Pa.), M. E. Campbell, and M. T. Lavik (Midwest Research Institute, Kansas City, Mo.), p. 345, 346; Author's Closure, p. 346, 347. 14 refs.

A67-21036 *

LUBRICANT LIFE TESTS ON BALL BEARINGS FOR SPACE APPLICATIONS.

S. F. Murray, Paul Lewis (Mechanical Technology, Inc., Latham, N.Y.), and A. J. Babecki (NASA, Goddard Space Flight Center, Greenbelt, Md.).

(American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 7A3.)
ASLE Transactions, vol. 9, Oct. 1966, p. 348-360; Discussion, M. J. Devine (U.S. Naval Air Engineering Center, Aeronautical Materials Laboratory, Philadelphia, Pa.), p. 360; Author's Closure, p. 360. 5 refs.
Contract No. NAS 5-9028.

A67-21037

PREDICTION OF BALL-SPIN AND INTERFACIAL SLIP FRICTION FROM ROOM TO 2500°F.

A. R. Leveille, C. J. Zupkus, and H. R. Ludwig (General Motors Corp., New Departure-Hyatt Bearings Div., Bristol, Conn.).

(American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 5D4.)
ASLE Transactions, vol. 9, Oct. 1966, p. 361-371. 11 refs.
Contract No. AF 33(615)-1208.

A67-21041

THE EFFECT OF GEOMETRY VARIATIONS ON HYDRODYNAMIC BEARING PERFORMANCE.

Donald S. Wilson (Mechanical Technology, Inc., Latham, N.Y.).
(American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 3-5, 1966, Paper.)
ASLE Transactions, vol. 9, Oct. 1966, p. 411-419.
Contract No. NObsr-87522.

Evaluations of the effects of such variables as out-of-roundness, taper, and surface finish on gas bearing components to determine reasonable bearing tolerances. It was found that variations in diameter of the rotating member can generally be averaged out for predicting performance. However, the effect of imperfections of the stationary bearing component becomes a function of their location relative to the pressure producing region of the bearing and makes the prediction of characteristic performance results difficult. B.B.

A67-21705
IMPROVED PHENOTHIAZINE ANTIOXIDANTS FOR SYNTHETIC LUBRICANTS.
Harold O. Strange, Joseph J. McGrath, and John P. Pellegrini, Jr. (Gulf Research and Development Co., New Products Div., Pittsburgh, Pa.).
I &EC - Industrial and Engineering Chemistry, Product Research and Development, vol. 6, Mar. 1967, p. 33-35. 14 refs.

Phenothiazine carboxylic acid esters are more effective antioxidants than phenothiazine on a molar basis in diester oils. No "phenothiazine sludge" occurs with these esters such as is observed with phenothiazine at temperatures above 300°F. By means of a laboratory oxidation test, such inhibited oils (20-ml samples) are found to be stable and sludge-free for up to 72 hr at air flow rates up to 8 liters/hr at 347°F, and in the presence of metals at the standard air flow rate of 1 liter per hour. When tested at temperatures up to 425°F, these inhibited oils showed a definite superiority to phenothiazine-inhibited blends by the complete absence of any oxidative sludge. These phenothiazine carboxylic acid esters probably yield soluble oxidation products but also may function as mild detergents or dispersants, the exact mechanism not being clear. (Author)

A67-22182
THE SOLUBILITY OF OXYGEN IN FUSED CARBONATES AND THE CORROSION BEHAVIOUR OF SILVER AND COPPER OXIDE AIR-CO_2 CATHODES IN MOLTEN CARBONATE FUEL CELLS.
M. Schenke and G. H. J. Broers (Nederlandse Centrale Organisatie T.N.O., Centraal Technisch Instituut; Amsterdam, University, Laboratory for Electrochemistry, Amsterdam, Netherlands).
Joint Services Electrical Power Sources Committee, International Power Source Symposium, Brighton, Sussex, England, Sept. 20-22, 1966, Paper. 22 p. 23 refs.

Experimental study of the solubility of O_2 in non-eutectic and eutectic ternary mixtures of Li_2CO_3, Na_2CO_3, and K_2CO_3 and in the eutectic binary system Li_2CO_3-Na_2CO_3, as a function of temperature. The amperometric titration method used is described. Also studied are the solubility of Ag in alkaline carbonates and the corrosion behavior of Ag and CuO electrodes. V.Z.

A67-22190
LUBRICATION AND WEAR; INSTITUTION OF MECHANICAL ENGINEERS, LUBRICATION AND WEAR GROUP, CONVENTION, 4TH, SCHEVENINGEN, NETHERLANDS, MAY 12-14, 1966, PROCEEDINGS.
London, Institution of Mechanical Engineers (Proceedings 1965-66. Volume 180. Part IIIK), 1966. 325 p.

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THE ACTION OF THE PARALLEL-SURFACE THRUST BEARING. C. M. M. Ettles and A. Cameron (London, University, London, England), p. 61-75, 304, 305, 308, 310, 311, 313, 314. 18 refs. [See A67-22192 09-15]
FILM THICKNESSES IN ELASTOHYDRODYNAMIC LUBRICATION BY SILICONE FLUIDS. A. Dyson and A. R. Wilson (Shell Research, Ltd., Chester, Ches., England), p. 97-112, 306, 314. 19 refs. [See A67-22193 09-15]
A CONSIDERATION OF FACTORS AFFECTING THE WEAR RESISTANCE OF MATERIALS USED IN AIRCRAFT GAS-TURBINE ENGINES. A. C. Jesper (Rolls-Royce, Ltd., Derby, England), p. 265-276, 298, 316, 317. 21 refs. [See A67-22194 09-15]
THE INVESTIGATION OF UNUSUAL BEARING FAILURES. F. T. Barwell (Wales, University, Swansea, Wales) and D. Scott (Ministry of Technology, East Kilbride, Scotland), p. 277-298, p. 302-305, 317. 40 refs. [See A67-22195 09-15]
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A67-22193
FILM THICKNESSES IN ELASTOHYDRODYNAMIC LUBRICATION BY SILICONE FLUIDS.
A. Dyson and A. R. Wilson (Shell Research, Ltd., Thornton Research Centre, Chester, Ches., England).
IN: LUBRICATION AND WEAR; INSTITUTION OF MECHANICAL ENGINEERS, LUBRICATION AND WEAR GROUP, CONVENTION, 4TH, SCHEVENINGEN, NETHERLANDS, MAY 12-14, 1966, PROCEEDINGS. [A67-22190 09-15]
London, Institution of Mechanical Engineers (Proceedings 1965-66. Volume 180. Part IIIK), 1966, p. 97-112; Communications, F. C. Carpenter (Smiths Industries, Ltd., Cheltenham, Glos., England), p. 306; Authors' Reply, p. 314. 19 refs.

Study showing that there is evidence that the behavior of viscoelastic liquids in continuous shear is related to their behavior in oscillatory shear. Published information is used about the behavior of silicones in oscillatory shear in order to predict their behavior in continuous shear, under the conditions of interest in elastohydrodynamic lubrication. It is found that this behavior can be described approximately as that of a "power-law" liquid, with a shear stress proportional to the shear rate raised to some power less than unity. This simple description is used to calculate film thicknesses in elastohydrodynamic lubrication, and the calculations are compared with the experimental results. M.F.

A67-22194
A CONSIDERATION OF FACTORS AFFECTING THE WEAR RESISTANCE OF MATERIALS USED IN AIRCRAFT GAS-TURBINE ENGINES.
A. C. Jesper (Rolls-Royce, Ltd., Derby, England).
IN: LUBRICATION AND WEAR; INSTITUTION OF MECHANICAL ENGINEERS, LUBRICATION AND WEAR GROUP, CONVENTION, 4TH, SCHEVENINGEN, NETHERLANDS, MAY 12-14, 1966, PROCEEDINGS. [A67-22190 09-15]
London, Institution of Mechanical Engineers (Proceedings 1965-66. Volume 180. Part IIIK), 1966, p. 265-276; Discussion, K. W. Burns and B. A. Hill, p. 298; Author's Reply, p. 316, 317. 21 refs.

Despite the increasing need for engineering materials to be wear-resistant, wear has usually been considered only after all other design factors, and frequently not at all. This is undesirable and all locating surfaces should be regarded with suspicion at the design stage, particularly with a view to lessening and facilitating repairs. Some effects on wear, of load and movement, vibration, temperature and material are discussed and the undesirability of rattling loads emphasized. The influence of surface oxides is discussed and the results of some other investigators related to practical experience of flight engine components. A rubbing test and a hammer test are described and from their results and the observations of two other authors, it is suggested that all the more wear resistant materials rely upon the formation of a Buckley and Johnson surface "glaze" whose characteristics are dependent upon the base material composition. It is further suggested that such materials will exhibit an impact limit beyond which the glaze will have a limited ability to survive, suggesting that the most promising line of approach to wear resistance is in the field of complex oxides. (Author)

A67-22195
THE INVESTIGATION OF UNUSUAL BEARING FAILURES.

F. T. Barwell (Wales, University, Swansea, Wales) and D. Scott (Ministry of Technology, National Engineering Laboratory, East Kilbride, Scotland).
IN: LUBRICATION AND WEAR; INSTITUTION OF MECHANICAL ENGINEERS, LUBRICATION AND WEAR GROUP, CONVENTION, 4TH, SCHEWENINGEN, NETHERLANDS, MAY 12-14, 1966, PROCEEDINGS. [A67-22190 09-15]
London, Institution of Mechanical Engineers (Proceedings 1965-66. Volume 180. Part IIIK), 1966, p. 277-297; Discussion, K. W. Burns and B. A. Hill, p. 298; G. Salomon (Nederlandse Centrale Organisatie TNO, Centraal Laboratorium, Delft, Netherlands), p. 302, 303; F. H. Towler (Towler Brothers /Patents/, Ltd., Leeds, England), p. 304, 305; Authors' Reply, p. 317. 40 refs.

Examination of the problem of diagnosing bearing failures as a first step toward eliminating them by design improvement. The importance of accurately determining the applied conditions is illustrated by the case of a rolling mill bearing which was intended to carry a load of 350 tons but was actually subjected to loading of more than 1700 tons. Unusual failures require to be investigated by all available laboratory techniques as specific fine-scale information from each technique enables a comprehensive elucidation of the mechanism of failure to be achieved. Simulated laboratory tests and a considerable research effort on an interdisciplinary basis are usually initiated to confirm postulates regarding the causes of failure and to determine the controlling factors. M. F.

A67-22248
THE IGNITION OF FLAMMABLE FLUIDS BY HOT SURFACES.
D. G. Goodall and R. Ingle (Rolls-Royce, Ltd., Fire Precautions Dept., Derby, England).
IN: FIRE RESISTANCE OF HYDRAULIC FLUIDS; SYMPOSIUM PRESENTED AT A MEETING OF THE AMERICAN SOCIETY FOR TESTING AND MATERIALS, AND THE SOCIETY OF AUTOMOTIVE ENGINEERS, NEW ORLEANS, LA., JANUARY 26, 27, 1966, PAPERS. [A67-22244 09-18]
Symposium sponsored by the Committee D-2 on Petroleum Products and Lubricants of the American Society for Testing and Materials, and the Committee A-6 on Aerospace Fluid Power Technology of the Society of Automotive Engineers.
Philadelphia, American Society for Testing and Materials (ASTM Special Technical Publication No. 406), 1966, p. 64-104.

Attempt to establish a thermal correlation for a particular fluid which would enable the risk of ignition to be calculated at the design stage. Tests were carried out on two rigs, both incorporating a hot bottom plate surface onto which the test fluid was sprayed, the side walls and top plate being somewhat cooler. The first rig was a static one in which top and bottom plate temperatures and the gap between them was varied. The effects of mixture strength, atomization, and wall materials were studied for kerosine, and the ignition temperatures for various fluids were determined for a limited number of configurations. The second rig consisted of a small wind tunnel in which the effect of air velocities up to 10 ft/sec and altitudes up to 20,000 ft were investigated. It is shown that air velocities up to 3 ft/sec have a large effect on spontaneous ignition temperatures. A correlation based on gas temperature and distance from the nearest wall shows good agreement for the static and wind tunnel rigs and for closed-vessel tests of other investigations. F. R. L.

A67-22421
ADVANCED AEROSPACE GREASES.
John B. Christian (USAF, Systems Command, Research and Technology Div., Materials Laboratory, Wright-Patterson AFB, Ohio) and Kemp R. Bunting (American Oil Co., Whiting, Ind.).
(American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 3C2.)
Lubrication Engineering, vol. 23, Feb. 1967, p. 52-56.

A67-22533
ROTOR-BEARING DYNAMICS OF HIGH-SPEED TURBOMACHINERY.
B. Sternlicht (Mechanical Technology, Inc., Latham, N.Y.).
Society of Automotive Engineers, Automotive Engineering Congress, Detroit, Mich., Jan. 9-13, 1967, Paper 670059. 17 p. 57 refs.
Members, $0.75; nonmembers, $1.00.

Discussion of fluid-film and rolling-element bearings and their influence on the rotor dynamics of high-speed turbomachinery. System critical speeds, rotor response to imbalance, instability, and turbulence are examined. The types of fluid-film bearings best suited for high-speed operation are identified. Examples of high-speed turbomachinery employing rolling-element, liquid-film, and gas bearings are included. V. P.

A67-22535
NONLINEAR VIBRATION DAMPING FUNCTIONS FOR FLUID FILM BEARINGS.
Homer J. Wood (PowerDynetics, Inc.).
Society of Automotive Engineers, Automotive Engineering Congress, Detroit, Mich., Jan. 9-13, 1967, Paper 670061. 14 p. 11 refs.
Members, $0.75; nonmembers, $1.00.
Research supported by Continental Aviation and Engineering, Deere and Co., and the United Aircraft Corp.

Curve-fitting functions are combined with transfer functions and special parameter groupings to demonstrate that amplitude-limiting effects of hydrodynamic bearings on vibrations associated with critical speeds of flexible rotors are due to nonlinear characteristics. It is shown that stable and/or critically-damped operation can be achieved by designing bearings within proper ranges of a "dynamic load number" and controlling unbalance expressed as principal axis deviation related to clearance. The form of the attitude angle function is shown to be particularly significant with respect to unbalance tolerance. Practical application techniques are illustrated.
(Author)

A67-22537 #
SHAFT, BEARING AND SEAL SYSTEMS FOR A SMALL ENGINE.
Richard P. Shevchenko (United Aircraft Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.).
Society of Automotive Engineers, Automotive Engineering Congress, Detroit, Mich., Jan. 9-13, 1967, Paper 670064. 10 p.
Members, $0.75; nonmembers, $1.00.

Discussion of the key mechanical difficulties inherent in designing shaft, bearing, and seal systems for three high-speed turbine engines. A review is made of the bearing, shaft, and seal system of a family of large turbine engines which has demonstrated its high reliability, high efficiency, and low cost per unit of power as the thermodynamic, material, and structural component technology has been improved and as the design power requirement has been reduced. Three different solutions to the problems discussed are presented: two for sophisticated, efficient engines for weapon systems consideration and the third for a potential industrial, low-cost, high-efficiency, moderately heavy engine. M. F.

A67-22613
ROTOR UNBALANCE IN GAS LUBRICATED BEARINGS.
Neville Tully (Portsmouth College of Technology, Portsmouth, Hants., England).
The Engineer, vol. 223, Feb. 24, 1967, p. 306-308. 5 refs.

Calculation of the amplitudes of vibration generated by unbalance loading in aerodynamic bearings under low static loading using Raimondi design charts. There is evidence of a critical unbalance-to-clearance ratio below which resonance might be run through, but above which bearing failure might occur. It is said to be also possible to use the results to predict the regions of half-speed whirl. B. B.

A67-22705 #
GAS LUBRICATION AND DISTORTION OF HIGH-PRESSURE MAINSHAFT SEALS FOR COMPRESSORS.
S. S. Bupara, J. A. Walowit, and C. M. Allen (Battelle Memorial Institute, Columbus Laboratories, Columbus, Ohio).
British Hydromechanics Research Association, International Conference on Fluid Sealing, 3rd, Cambridge, England, Apr. 3-5, 1967, Paper B3. 24 p. 7 refs.

Theoretical analyses and static experiments have been performed for high-pressure, gas-lubricated face seals of the type used as mainshaft seals for jet-engine compressors. The analyses

consider the combined effects of seal-element distortion and gas flow through the seal interface. The analytical results indicate that optimum stability with respect to small equilibrium parallel disturbances occur when the upstream film thickness is approximately three times as great as the downstream film thickness. The analysis provides methods for designing the seal so that it distorts under pressure to the desired film-thickness profile. A critical parameter governing the distortion is found to be the positioning of the secondary seal. Static film-thickness profiles have been measured interferometrically, which show the predicted and measured seal distortions to be in excellent agreement. Measured film thicknesses are found to be in reasonably good agreement with predicted ones. This agreement can be improved by approximately accounting for axial forces imposed by the elastomeric secondary seal upon the stator. A fair amount of discrepancy was found to exist between measured and predicted leakage rates; however, on consideration of the fact that leakage varies approximately with the third power of the film thickness, this discrepancy is not excessive. (Author)

A67-22829

INVESTIGATION OF THE CHEMICAL STABILITY OF SOLID LUBRICANTS AT HIGH TEMPERATURES. I.

M. E. Belitskii (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukrainian SSR).

(Poroshkovaia Metallurgiia, vol. 6, Apr. 1966, p. 40-44.)
Soviet Powder Metallurgy and Metal Ceramics, Apr. 1966, p. 293-296. 7 refs. Translation.

A67-22831

THE LIFE OF POROUS BEARINGS RELATIVE TO THE GRADE OF IMPREGNATING LUBRICANTS.

V. D. Zozulia (Akademiia Nauk Ukrainskoi SSR, Institut Problem Materialovedeniia, Kiev, Ukrainian SSR).

(Poroshkovaia Metallurgiia, vol. 6, May 1966, p. 103-106.)
Soviet Powder Metallurgy and Metal Ceramics, May 1966, p. 427-429. 5 refs. Translation.

A67-22867

THE INFLUENCE OF SUBSTRATE HARDNESS ON THE FORMATION AND ENDURANCE OF MOLYBDENUM DISULPHIDE FILMS.

J. K. Lancaster (Ministry of Aviation, Royal Aircraft Establishment, Chemistry, Physics and Metallurgy Dept., Farnborough, Hants., England).

Wear, vol. 10, Mar.-Apr. 1967, p. 103-117. 12 refs.

Observation that the hardness of a substrate metal affects the performance of MoS_2 as a solid lubricant in two ways. Soft-metal substrates facilitate adhesion and harder substrates facilitate cohesion. An effective compromise between these conflicting factors is achieved by precoating a hard substrate with a thin film of a softer metal. Soft-metal coatings are synergistic with MoS_2 and enhance its performance as a solid lubricant. Measurements of the rates of wear of different metals lubricated by MoS_2 show that the most important factor in the wear process is abrasion by the MoS_2 itself. M. M.

A67-23009

STRESS CORROSION OF EXPLOSIVELY DEFORMED HIGH STRENGTH ALLOYS.

K. R. Agricola and J. T. Snyder (Martin Marietta Corp., Martin Co., Ordnance Applications Laboratory, Denver, Colo.).

Society for Nondestructive Testing, American Society for Metals, American Society of Tool and Manufacturing Engineers, Annual Western Metal and Tool Conference and Exposition, 4th, Los Angeles, Calif., Mar. 13-17, 1967, Paper WES 7-63. 17 p. 9 refs.
Contract No. AF 33(615)-3167.

Four high strength steels and one high strength aluminum alloy were evaluated before and after explosive deformation to establish the effects of forming on stress-corrosion resistance. Alternate immersion in a 3-1/2% NaCl solution for up to 200 hr was accomplished. Specimens were stressed to 80% of the 0.2% offset tensile yield strength. From the steels, only the 18% nickel maraging steel showed an appreciable effect of stress corrosion on the reduction in mechanical properties. The 7039-T62 aluminum was also adversely affected. Explosive deformation did not cause any detrimental effects on properties after alternate exposure for the steels evaluated; however, the effect of high energy forming on stress corrosion susceptibility of 7039-T62 aluminum was significant. (Author)

A67-23411

JET AIRCRAFT ACCESSORIES.

Lubrication, vol. 53, no. 2, 1967, p. 17-24.

Discussion of factors affecting the lubrication of jet aircraft accessories. It is pointed out that the oil may be used as a hydraulic fluid to control the operation of turbo-compressors; it may be used as a power transmission medium in constant speed drives; it may be subjected to contamination by water, dirt and wear debris; and lastly it may be exposed to high surface temperatures such as may be encountered in auxiliary power units. In addition to all of these factors, the oil must lubricate a wide variety of metal combinations, bearings, servo valves, and gears. It must also provide adequate cooling. Additionally, the oil must be readily wicked so as to be transported to the areas where lubrication is desired. Type I and II oils normally used for jet engine lubrication are generally satisfactory for all accessories, with some limitations imposed by the low-temperature starting requirements of certain equipment. M. M.

A67-23701 * #

STRESS CORROSION CRACKING OF TITANIUM ALLOYS.

T. R. Beck and M. J. Blackburn (Boeing Co., Boeing Scientific Research Laboratories, Seattle, Wash.).

IN: AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, AND AMERICAN SOCIETY OF MECHANICAL ENGINEERS, STRUCTURES, STRUCTURAL DYNAMICS AND MATERIALS CONFERENCE, 8TH, PALM SPRINGS, CALIF., MARCH 29-31, 1967, TECHNICAL PAPERS. [A67-23696 10-32]
New York, American Institute of Aeronautics and Astronautics, Inc., 1967, p. 39-47. 17 refs.
Contract No. NAS 7-489.

Although much applied research has been done and titanium alloys of minimum susceptibility have been found, little understanding exists on the basic mechanisms of stress corrosion cracking (SCC) of titanium. Brief descriptions of recent electrochemical and metallurgical measurements and a new theoretical model for SCC of titanium alloys are presented here. Tensile tests were conducted with notched titanium alloy specimens in air and in various solvents and salt solutions. Concurrently, studies of titanium phases, dislocation arrangements and fractography were made. Of the many ions investigated, only chloride, bromide and iodide produce SCC, and parts per million concentration of these in the environment is sufficient. Inhibition is complete with a large excess of certain inhibiting anions in the environment. Ultimate strength and crack propagation velocity is strongly dependent upon electrochemical potential of specimens in the halide solutions. Fracture is transcrystalline in the α-phase and is strongly related to aluminum content and heat treatment of the titanium alloy; and appears to correlate with a marked change in dislocation arrangement at about 6% aluminum. (Author)

A67-23918

HOT CORROSION OF GAS TURBINE ALLOYS.

P. A. Bergman (General Electric Co., Thomson Engineering Laboratory, Lynn, Mass.).

(National Association of Corrosion Engineers, Conference, 23rd, Los Angeles, Calif., Mar. 13-16, 1967, Paper.)
Corrosion, vol. 23, Mar. 1967, p. 72-81. 14 refs.

Types of hot corrosion encountered in aircraft gas turbines operating in marine environments were reproduced in laboratory tests. Nickel and cobalt-base alloys were tested in the products of combustion of JP-5 and 0, 2 and 200 ppm sea salt between 1600°F (871°C) and 2000°F (1093°C). Higher chromium alloys were generally (but not always) more resistant to hot corrosion. Attack was caused by sodium sulfate, corrosion occurring only in the temperature range in which sodium sulfate was deposited in a molten state. (About 1600°F (871°C) to 1875°F (1024°C)/2000°F (1093°C). Effects of another alkali metal and two alkaline-earth metals, sulfur and

chlorine also were evaluated. Microstructural changes were studied by metallographic techniques and chemical compositional changes and sulfides were identified by electron microprobe analyses. The nature of attack is discussed and some concepts of the hot corrosion mechanism postulated. Apparently, depletion of chromium in surface zones through the formation of oxides and sulfides reduces the corrosion resistance of depleted zones, thereby promoting severe hot corrosion. (Author)

A67-23982
THE COLD STARTING AND SERVICE TEST EVALUATION OF AN SAE 10W30 AIRCRAFT ENGINE OIL.
Bruce N. Marks (Cessna Aircraft Co., Wichita, Kan.).
Society of Automotive Engineers, Business Aircraft Conference, Wichita, Kan., Apr. 5-7, 1967, Paper 670249. 10 p.
Members, $0.75; nonmembers, $1.00.

Results of service evaluation and cold-cranking and starting tests on an experimental SAE 10W30 aviation oil compounded at the request of the aircraft manufacturer. Starting tests performed at 0°F showed that with all engine conditions normal (standard SAE 30 aircraft engine oil, external power source, and functioning prime system), an engine start is unlikely. Faster cranking speeds can be obtained through the use of less viscous lubricating oils. The experimental oil, compounded to promote easier cold weather starting, and offering adequate protection at normal operating temperatures, is discussed, and comparisons are drawn between this oil and other available multiviscosity oils. Results from cold weather starting tests as well as a service test program performed to support the use of the 10W30 oil under normal hot weather operating conditions are presented. F.R.L.

A67-24531 #
WEAR AND CHANGE IN PARAMETERS OF THE AXIAL AND CENTRIFUGAL COMPRESSOR STAGES DUE TO OPERATION IN DUSTY AIR [IZNOS I IZMENENIE PARAMETROV OSEVOI I TSENTROBEZHNOI STUPENEI KOMPRESSORA PRI RABOTE NA ZAPYLENNOM VOZDUKHE].
Iu. I. Shal'man.
IN: HELICOPTER GAS-TURBINE ENGINES [VERTOLETNYE GAZOTURBINNYE DVIGATELI].
Edited by M. M. Maslennikov.
Moscow, Izdatel'stvo Mashinostroenie, 1966, p. 163-199. 10 refs.
In Russian.

Experimental investigation of the impact- and abrasion-wear of helicopter compressor stages due to dust intake. It is shown that the absolute value of wear is directly proportional to the velocity of particle impact against the blades and increases with particle size. The magnitude of blade wear as a function of the relative effect of particle size is found to be the same for stator blades, the axial stage, and the centrifugal compressor. The resistance of steel blades to wear exceeds that of Duralumin by a factor of 2.7. V.P.

A67-24586 *
STRESS-CORROSION CRACKING OF COLD-REDUCED AUSTENITIC STAINLESS STEELS.
H. L. Logan and M. J. McBee (National Bureau of Standards, Metallurgy Div., Corrosion Section, Washington, D.C.).
Materials Research and Standards, vol. 7, Apr. 1967, p. 137-145. 5 refs.
NASA-supported research.

The effects of specimen orientation with respect to the direction of rolling or prior rolling on the susceptibility to stress-corrosion cracking in a boiling $MgCl_2$ solution were determined for both annealed and cold-reduced types 301, 304, 310, and 321 stainless steels. Threshold stresses for the most susceptible orientations were determined in a boiling 0.5 N NaCl, 0.1 N $NaNO_2$ solution to be 60 to 110% of the yield strengths of the materials. None of the steels cracked in a marine atmosphere during 15 months exposure stressed at 90% of their yield strengths. The effects on the threshold stresses of varying amounts of cold work differed from steel to steel and are reported. The effects of internal stress patterns and welding were also investigated for some of these steels and are described. (Author)

A67-24790 #
EFFECTS OF TURBINE ATMOSPHERES ON SULFIDATION CORROSION.
M. J. Donachie, Jr., R. A. Sprague, F. P. Talboom, and E. F. Bradley (United Aircraft Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.).
American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 5-9, 1967, Paper 67-GT-2. 13 p. 16 refs.
Members, $0.75; nonmembers, $1.50.

Study of sulfidation effects on turbine blades in a salt environment. Temperature ranges of interest in sulfidation were delineated. In burner rig testing, present procedures require weight-change and metal-loss curves to be generated by the periodic examination of specimens, normally at about 20-hr intervals, in the temperature range of 1450-2150°F. The curves are established by weight-change measurements prior to a descaling operation and by micrometer evaluation of metal loss where feasible. At the end of testing, metallographic examinations are performed on transverse sections at intervals along the wedge specimen. Tests on a wide variety of nickel and cobalt base alloys were made in burner rigs, and the visual appearance of sulfidation test specimens is shown. The results of such tests may be interpreted in terms of the effects of salt, fuel sulfur content, cycle, temperature, and alloy composition. R.B.S.

A67-24791 #
A COMPARISON OF OIL AND GAS LUBRICATION SYSTEMS FOR CLOSED-LOOP GAS-TURBINE MACHINERY.
P. W. Curwen, R. A. Harmon (Mechanical Technology, Inc., Latham, N.Y.), and G. B. Manning (U.S. Army, Combat Development Command, Army Engineers Reactors Group, Nuclear Power Field Office, Fort Belvoir, Va.).
American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 5-9, 1967, Paper 67-GT-3. 14 p. 18 refs.
Members, $0.75; nonmembers, $1.50.

Discussion of the lubrication system design and component arrangements for several oil and gas-lubricated closed-loop gas-turbine machines. The demonstrated advantages inherent in the gas-lubrication concept (such as superior cooling characteristics and simpler design) are treated. Potential problem areas in the field of gas lubricated bearings are discussed. R.B.S.

A67-24793 #
THE EFFECTS OF MICROSTRUCTURAL VARIATIONS ON STRESS-CORROSION CRACKING SUSCEPTIBILITY OF Ti-8Al-1Mo-1V ALLOY ON MARINIZED GAS TURBINES.
W. P. Danesi, M. J. Donachie, Jr., and R. A. Sprague (United Aircraft Corp., Pratt and Whitney Aircraft Div., Materials Development Laboratory, East Hartford, Conn.).
American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 5-9, 1967, Paper 67-GT-5. 10 p. 10 refs.
Members, $0.75; nonmembers, $1.50.

Investigation of microstructural variations of Ti-8Al-1Mo-1V alloy due to stress corrosion cracking. Samples were generally coated with a salt slurry and dried prior to testing; other tests were run in dynamic salt-air environments. It is pointed out that stress-corrosion cracking can occur regardless of microstructural conditions if a sufficient stress is applied, but significant improvements in salt stress-corrosion resistance of titanium can be achieved by proper alloy microstructure control through heat treatment. In particular, it was shown that a heat-treat anneal just below the beta transus can raise the stress level for crack susceptibility at 800°F by 67%. Charts showing stress vs temperature are given, and the microstructure of the alloy after testing is illustrated. R.B.S.

A67-24801 #
THE MATERIALS CHALLENGE OF HIGH-TEMPERATURE TURBINE VANES AND BLADES.

W. R. Martens and W. A. Raabe (United Aircraft Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.).
American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, Houston, Tex., Mar. 5-9, 1967, Paper 67-GT-17. 8 p.
Members, $0.75; nonmembers, $1.50.

Discussion of creep, corrosion, and thermal fatigue occurring in turbine blades, with emphasis on the relationship between these failure modes and inlet temperature (absolute temperature or the rate of temperature change). Plots showing the increase in inlet temperature through the years and the improvement in creep strength of blade alloys are given. Strain ranges for air-cooled and non-cooled blades are compared. R.B.S.

A67-24940 *
CORROSION CONTROL AT THE CAPE - ENVIRONMENT AT CAPE KENNEDY IDEAL FOR CORROSION.
Stephen G. Pinney (NASA, Kennedy Space Center, Cape Kennedy, Fla.).
Materials Protection, vol. 6, Apr. 1967, p. 38, 39.

Discussion of some of the corrosion problems and methods used to solve them at Cape Kennedy. Subjects discussed include initial structure design (to prevent corrosion), protection of a structure after modifications are made, importance of coatings application techniques, and protective coatings specifications. M.F.

A67-25127 #
CORROSION PROBLEMS IN AIRCRAFT.
A. Holt (Hawker Siddeley Aviation, Ltd., Engineering Research Dept., Manchester, England).
Tech Air, vol. 23, Apr. 1967, p. 8, 9.

Brief survey of corrosion problems in aircraft design. Two general types of corrosion are treated, namely simple corrosion and stress corrosion. The protection of joints is one of the more taxing problems discussed. Several other problem areas are examined, including bilges, honeycomb sandwiches, and magnesium alloys. R.B.S.

A67-25327
INSTITUTION OF MECHANICAL ENGINEERS, LUBRICATION AND WEAR CONVENTION, 5TH, PLYMOUTH, ENGLAND, MAY 4-6, 1967, PAPERS.
London, Institution of Mechanical Engineers, 1967. 223 p.

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DEVELOPMENT OF A HIGH-SPEED LINEAR BEARING FOR CATAPULTS. C. C. Mitchell (Brown Brothers and Co., Ltd., Edinburgh, Scotland) and F. J. Buesnel (Ministry of Aviation, Royal Aircraft Establishment, Bedford, England), p. 11-19. [See A67-25328 12-15]

METALLURGICAL ASPECTS OF ROLLING CONTACT FATIGUE. D. Scott, B. Loy, and G. Mills (Ministry of Technology, National Engineering Laboratory, East Kilbride, Scotland), p. 83-92. 37 refs. [See A67-25329 12-17]

VARIABILITY WITH TIME OF BEARING CLEARANCE DUE TO TEMPERATURE AND PRESSURE. K. Czeguhn (Karlsruhe, Technische Hochschule, Karlsruhe, West Germany), p. 216-223. 5 refs. [See A67-25330 12-15]

A67-25330
VARIABILITY WITH TIME OF BEARING CLEARANCE DUE TO TEMPERATURE AND PRESSURE.
K. Czeguhn (Karlsruhe, Technische Hochschule, Lehrstuhl für Maschinen-Konstruktionslehre und Kraftfahrzeugbau and Institut für Maschinen-Konstruktionslehre und Kraftfahrzeugbau, Karlsruhe, West Germany).
IN: INSTITUTION OF MECHANICAL ENGINEERS, LUBRICATION AND WEAR CONVENTION, 5TH, PLYMOUTH, ENGLAND, MAY 4-6, 1967, PAPERS. [A67-25327 12-15]
London, Institution of Mechanical Engineers, 1967, p. 216-223. 5 refs.

A method of calculation is described which allows the effects in time of temperature and pressure on bearing clearances to be investigated. The method is based on the fundamental hydrodynamic equation, the Fourier heat conduction equation, and the thermoelastic equations, and combines these in a suitable manner. The iterative-numerical treatment of the calculations allows characteristic quantities, such as the revolutions per minute, to be altered during the course of the calculation. In order to simplify the calculations, an infinitely long bearing with lemon-shaped clearance and a centrally running shaft is assumed. This does not imply any limitation to the general applicability of the method, but merely serves as a means of reducing the effort required for the calculation work. (Author)

A67-25358
STUDY OF THE CORROSION PROPERTIES OF YTTRIUM. I.
R. M. Al'tovskii, A. G. Fedotova, and S. I. Korolev.
(Zashchita Metallov, vol. 2, Jan.-Feb. 1966, p. 52-56.)
Protection of Metals, vol. 2, Jan.-Feb. 1966, p. 43-46. 8 refs.
Translation.

A67-25359
CORROSION AND ELECTROCHEMICAL BEHAVIOR OF RHENIUM.
N. D. Tomashov and T. V. Matveeva (Akademiia Nauk SSSR, Institut Fizicheskoi Khimii, Moscow, USSR).
(Zashchita Metallov, vol. 2, Jan.-Feb. 1966, p. 57-62.)
Protection of Metals, vol. 2, Jan.-Feb. 1966, p. 47-51. 7 refs.
Translation.
[For abstract see issue 10, page 1546, Accession no. A66-21748]

A67-25502
PRESENT DAY LUBRICANTS FOR UTILITY AIRCRAFT ENGINES.
H. A. Poitz (Shell Oil Co., Houston, Tex.).
Society of Automotive Engineers, Business Aircraft Conference, Wichita, Kan., Apr. 5-7, 1967, Paper 670248. 8 p. 11 refs.
Members, $0.75; nonmembers, $1.00.

Discussion of four basic kinds of lubricants for utility aircraft piston engines. The two major types are nonadditive straight mineral oil and ashless dispersant mineral oil; the two minor types are metallic additive detergent mineral oil and synthetic oil. The merits of each of these major types of oils are described, and their relative advantages in several categories are compared. It appears that the ashless dispersant mineral oil (MIL-L-22851) offers the most improvements for the least amount of money on the present market, but that potentially a synthetic oil may offer improvements in some applications even beyond the dispersant mineral oil. Straight mineral oil has the advantages of low cost, availability, and compatibility but may sometimes limit engine performance because of deposit formation, wear, and lack of low-temperature capabilities. F.R.L.

A67-25884
INITIAL EXPERIENCE WITH EMULSIFIED FUELS AT AVCO LYCOMING.
George Opdyke, Jr. (Avco Corp., Lycoming Div., Stratford, Conn.).
Society of Automotive Engineers, National Aeronautic Meeting, New York, N.Y., Apr. 24-27, 1967, Paper 670366. 10 p. 6 refs.
Members, $0.75; nonmembers, $1.00.
Army-supported research.

Discussion of feasibility testing of three emulsified fuels (two aqueous, one nonaqueous) in several gas turbine combustors, fuel controls, fuel system component parts, and in three Avco Lycoming gas turbine engine models. Engine operation was essentially unaffected at power levels normally used for low altitude flight, but combustion was inhibited at starting and at altitude conditions. In the T55 atomizing engine, the fuel control valves were corroded by the emulsions and the fuel injector nozzle screens were blocked with rust and dirt. The indications are that atomizing-combustor versions of these engines will operate satisfactorily with emulsions which are not corrosive and which can readily be de-emulsified in passing through the fuel system. R.B.S.

A67-25885
EMULSIFIED JET ENGINE FUEL.
Jay C. Harris and E. A. Steinmetz (Monsanto Research Corp., Dayton Laboratory, Dayton, Ohio).
Society of Automotive Engineers, National Aeronautic Meeting, New York, N.Y., Apr. 24-27, 1967, Paper 670365. 7 p. 12 refs.
Members, $0.75; nonmembers, $1.00.
Army-supported research.

Investigation of two high internal phase JP-4 fuel emulsions containing 3% external emulsifying phase. One of the emulsions is designed to permit JP-4 recovery for use in other vehicles. External phase characteristics are described which provide lowered JP-4 volatility and flammability, and which give emulsions stable at -20 to +135°F, are completely resistant to 500 g accelerations, and are corrosion resistant. The effectiveness of various types of emulsifiers and their peculiar requirement for these emulsions are discussed. Preparation, storage, pumpability, explosivity, evaporation rate, and flammability characteristics are described. R.B.S.

A67-25952 #
EFFECTS OF CORROSION ON TRANSDUCER PERFORMANCE.
Earl J. Rogers (Electro-Optical Systems, Inc., Micro-Systems Div., Pasadena, Calif.).
American Society of Mechanical Engineers, Metals Engineering Conference, Houston, Tex., Apr. 3-5, 1967, Paper 67-Met-14. 7 p.
Members, $0.75; nonmembers, $1.50.

In many component or system designs, corrosive environments can cause serious degradation in performance. These effects never can be eliminated completely, but should be considered during the design phase to determine the limitations of the device. This paper describes how corrosion effects can be predicted quantitatively as well as qualitatively. A pressure transducer, designed for short-term measurement of highly corrosive rocket propellants, is presented as an example. Data from transducers used on rocket-engine firings are presented to verify the analysis. Photomicrographs are included to analyze microscopic corrosion for the particular rocket propellants tested. (Author)

A67-26128
A CONTEMPORARY VIEW OF NICKEL-BASE SUPERALLOYS.
Chester T. Sims (General Electric Co., Materials and Processes Laboratory, Schenectady, N.Y.).
Journal of Metals, vol. 18, Oct. 1966, p. 1119-1130. 23 refs.

Review of the present state of technology of nickel-base superalloys with respect to contemporary requirements of structural stability and hot-corrosion resistance. The chemical composition, processing, and heat treatment of wrought and cast-nickel alloys are described in terms of structures and properties. The phenomena of hot-corrosion attack are analyzed, and a typical example of sulfidation attack on a nickel-base superalloy is given. Phase control is described in terms of the Phacomp (phase computation) method of avoiding the unwanted TCP (topologically close-packed) phases. Phacomp may be used to control or evaluate production heats of superalloys and as an alloy development tool, obviating much alloy preparation and testing to focus attention on the stable compositions of interest. The necessity for exercising care when using Phacomp is emphasized, and some of the problems which may arise are listed. T.M.

A67-26163 #
LUBRICITY OF JET FUELS.
J. K. Appeldoorn and W. G. Dukek (Esso Research and Engineering Co., Linden, N.J.).
(Society of Automotive Engineers, Aeronautic and Space Engineering and Manufacturing Meeting, Los Angeles, Calif., Oct. 3-7, 1966, Paper 660712.)
Esso Air World, vol. 19, Mar.-Apr. 1967, p. 118-124. 18 refs.
Contract No. AF 33(615)-2828.

A67-26351 #
STATIC CHARACTERISTICS OF A RADIAL GAS-DYNAMIC BEARING [STATICHESKIE KHARAKTERISTIKI RADIAL'NOGO GAZODINAMICHESKOGO PODSHIPNIKA].
Iu. R. Ivanov (Leningradskii Institut Aviatsionnogo Priborostroeniia, Leningrad, USSR).
Priborostroenie, vol. 10, no. 3, 1967, p. 83-86. 7 refs. In Russian.

Solution of the differential equation for the pressure distribution in a lubricating layer, obtained in a class of transient solutions in the space of the coordinate and the compressibility number. An approximate solution for a bearing of finite length is obtained on the basis of the solution for an infinite bearing. Analytical expressions for calculating the static characteristics of the bearing are obtained. A.B.K.

A67-26451 #
ANALYSIS OF THE STRESS-STRAIN STATE AND OF THE NATURE OF DAMAGE OF THE SURFACE LAYERS OF NOZZLE BLADES [ANALIZ NAPRIAZHENNOGO SOSTOIANIIA I KHARAKTER RAZRUSHENIIA POVERKHNOSTNYKH SLOEV SOPLOVYKH LOPATOK].
V. N. Gridnev and A. I. Efimov (Akademiia Nauk Ukrainskoi SSR, Institut Metallofiziki, Kiev, Ukrainian SSR).
IN: MECHANISM OF METAL BREAKDOWN [MEKHANIZM RAZRUSHENIIA METALLOV].
Edited by V. N. Svechnikov.
Kiev, Izdatel'stvo Naukova Dumka, 1966, p. 105-112. 13 refs.
In Russian.

Discussion of the stress-strain state and corrosion and erosion produced by aggressive gas flows in the surface layers of gas-turbine nozzle blades of ZhS6-K alloy. Residual stresses, thermal stresses, stresses due to the erosion of alloying elements, intermetallide phase formation, and gas corrosion at grain boundaries are the damaging agents discussed specifically. Photomicrographs of various types of damage are given. V.Z.

A67-27068 #
JET FUELS IN THE U.S. AND GREAT BRITAIN [REAKTIVNYE TOPLIVA SShA I ANGLII].
Ia. B. Chertkov, V. G. Spirkin, and V. M. Ignatov.
Khimiia i Tekhnologiia Topliv i Masel, vol. 12, Apr. 1967, p. 49-52. 14 refs. In Russian.

Evaluation of American and British jet fuels of the last 10 to 15 years. Chemical composition and technical specifications are given and fuel production technology is outlined. It is pointed out that the stability and corrosion effect of jet fuels depend more on the presence of unsaturated compounds and on the stability of S-compounds than merely on the presence of S, and that anti-oxidative additives markedly improve the thermal stability and corrosion properties of S-free fuels. V.Z.

A67-27100 *
STATUS OF LUBRICANTS FOR MANNED SPACECRAFT.
F. G. A. Delaat (TRW Systems Group, Redondo Beach, Calif.), R. V. Shelton (North American Aviation, Inc., Downey, Calif.), and J. H. Kimzey (NASA, Manned Spacecraft Center, Houston, Tex.).
(American Society of Lubrication Engineers, Annual Meeting, 21st, Pittsburgh, Pa., May 2-5, 1966, Paper 66AM 7A2.)
Lubrication Engineering, vol. 23, Apr. 1967, p. 145-153. 6 refs.

A67-27108
PROBLEMS OF THE CORROSION OF BERYLLIUM IN CO_2 UNDER PRESSURE AT HIGH TEMPERATURES [PROBLEMES DE CORROSION DU BERYLLIUM DANS LE GAZ CARBONIQUE SOUS PRESSION AUX TEMPERATURES ELEVEES].

J. Dewanckel, D. Leclerc, and R. Darras (Commissariat à l'Energie Atomique, Centre d'Etudes Nucléaires de Grenoble, Département de Métallurgie, Grenoble, France).
N: INTERNATIONAL CONFERENCE ON THE METALLURGY OF BERYLLIUM, GRENOBLE, FRANCE, MAY 17-20, 1965, PAPERS CONFERENCE INTERNATIONALE SUR LA METALLURGIE DU BERYLLIUM, GRENOBLE, FRANCE, MAY 17-20, 1965, PAPERS]. A67-27101 13-17]
Conference sponsored by the Société Française de Métallurgie.
Paris, Presses Universitaires de France, 1966, p. 171-191. 26 refs.
In French.

Study of the corrosion of different types of beryllium and of certain of its alloys in CO_2 under a pressure of 60 bars. The extreme sensitivity of the nonalloyed metal to the presence of water vapor is noted; water vapor causes scaling at 600°C which is followed by a pronounced and destructive intergranular corrosion. Several surface treatments - the application of oxide-rich metal or the the introduction of cargon monoxide into the CO_2 - bring only insignificant improvements. However, alloys containing at least 0.2% calcium or magnesium show excellent resistance to oxidation, even in damp CO_2. The role of water vapor in the gas, and the resistance to corrosion of weak calcium or magnesium additions are discussed.
M. F.

A67-27174
THE STRESS CORROSION OF METALS.
H. L. Logan (National Bureau of Standards, Metallurgy Div., Washington, D.C.).
New York, John Wiley and Sons, Inc., 1966. 316 p.
$13.95.

Stress corrosion cracking in the important alloy systems is discussed in detail together with theories of the mechanisms involved. The phenomena of the stress corrosion cracking of metals is analyzed in terms of the electrochemical process which initiates cracks and the progress of these cracks by an electrochemical-mechanical process. The intercrystalline or transcrystalline paths of cracks are discussed, and the role of the corrodent analyzed. The principal ways of reducing or avoiding damage from stress corrosion cracking are described. Separate chapters are devoted to stress corrosion cracking in low carbon steels, low alloy steels for aerospace applications, various types of stainless steels, copper, aluminum, nickel, magnesium, titanium, and precious metal alloy systems. In each chapter techniques for eliminating stress corrosion failures are suggested. An entire chapter is devoted to methods of identifying stress corrosion failures, determination of the environment in which a failure occurred, and subsequent tests of materials in equivalent environments. Methods that may be used for determining the susceptibility of metals to stress corrosion cracking are presented in a separate chapter.
T.M.

A67-27688 #
CORROSION OF METALS BY FLOWING LIQUID FLUORINE COMPOUNDS.
N. A. Tiner (Douglas Aircraft Co., Inc., Santa Monica, Calif.).
IN: ADVANCES IN CRYOGENIC ENGINEERING. VOLUME 12 - PROCEEDINGS OF THE TWELFTH ANNUAL CRYOGENIC ENGINEERING CONFERENCE, BOULDER, COLO., JUNE 13-15, 1966. [A67-27634 13-33]
Conference supported by the National Science Foundation, NSF Grant No. GK-1116.
Edited by K. D. Timmerhaus.
New York, Plenum Press, Division of Plenum Publishing Corp., 1967, p. 771-779. 14 refs.
Contract No. AF 33(657)-9162.

Description of apparatus developed to conduct accelerated corrosion tests of materials with fluorine oxidizers at cryogenic temperatures. The general test method developed is described, and the results obtained in tests with oxygen difluoride are summarized. It is concluded that through the simple testing method described it could be possible to conduct accelerated corrosion tests to evaluate relative resistance of materials to corrosion in flowing fluorine-containing liquid oxidizers.
M. M.

A67-27791
GEAR MATERIAL FOR OPERATION AT 1000 F.
Stanley Wallerstein (Fairchild Hiller Corp., Stratos Div., Bay Shore, N.Y.).
Metal Progress, vol. 91, May 1967, p. 89, 90.
USAF-sponsored research.

Development of new gear materials and methods of lubrication to satisfy increasing temperature requirements in aerospace applications. Tests proved the ability of a lubricant consisting of 83 1/3% graphite and 16 2/3% cadmium oxide to operate at high speeds and 1200°F. In rolling-disk evaluations and gear performance tests of three high-temperature alloys, a cobalt-base alloy (Haynes Stellite alloy No. 6B) gave the most promising results.
M. F.

A67-27806
RESISTANCE TO CORROSION AND STRESS CORROSION.
W. W. Binger, E. H. Hollingsworth, and D. O. Sprowls (Aluminum Company of America, Alcoa Research Laboratories, Chemical Metallurgy Div., New Kensington, Pa.).
IN: ALUMINUM. VOLUME 1 - PROPERTIES, PHYSICAL METALLURGY AND PHASE DIAGRAMS.
Edited by K. R. Van Horn.
Metals Park, Ohio, American Society for Metals, 1967, p. 209-276. 12 refs.

Survey of corrosion control and general resistance to corrosion and stress corrosion of various aluminum-alloy systems. Causes of corrosion of aluminum are investigated in terms of alloy constituents, metallurgical and thermal treatments, grain structure, effects of abrasions, temperature, galvanic currents, pressure, and the ratio of area to volume. The types of corrosive attack which are reviewed include: uniform attack, pitting, intergranular attack, stress-corrosion cracking, fretting corrosion, cavitation, and erosion. Methods of corrosion control by selecting alloys and temper utilizing inhibitors, passivators, cathodic protection, and protective coatings, and controlling sustained tension stress, and design conditions are described. General resistance of aluminum alloys to corrosion is analyzed. The effects of various atmospheric weathering conditions, water environments, soils, and chemicals are also described.
T.M.

A67-27889 #
HYDRODYNAMIC LUBRICATION IN FACE SEALS.
B. S. Nau.
British Hydromechanics Research Association, International Conference on Fluid Sealing, 3rd, Cambridge, England, Apr. 3-5, 1967, Paper E5. 48 p. 54 refs.

The literature of fundamental studies of face seals is reviewed in detail, with the emphasis on the conditions in the interface region. Attention is concentrated on hydrodynamic face seals, as opposed to those operating in the boundary lubrication regime. The evidence for the existence of a full fluid film between the faces is presented and the mechanisms responsible for its existence are discussed. Much of the experimental work is presented in a modified fashion, for convenience in making comparisons or in order to bring out the existence of certain relationships between variables which were not originally evident. Among the subjects covered are the effects of surface roughness; wear-rates; leakage and inward-pumping; friction and duty parameters; film thickness measurements; film temperatures and film pressures.
(Author)

A67-27999
IMPROVING FRICTIONAL BEHAVIOR WITH SURFACE TREATMENTS.
E. F. Bradley (United Aircraft Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.).
(American Society for Metals, American Society for Testing and Materials, and Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers, National Metal Congress, Chicago, Ill., Oct. 31-Nov. 3, 1966, Paper.)
Metals Engineering Quarterly, vol. 7, May 1967, p. 29-32.

Discussion of methods for the reduction of wear, galling, and scuffing in machinery due to the juxtaposition of metal surfaces. Methods to improve scuffing resistance depend on the use of dry-film lubricants, such as graphite and molybdenum disulfide. Galling and scuffing are controlled by hard facing materials and processes, including electroplated hard chromium, deep anodizing of aluminum, aluminizing, wear-resistant cobalt and nickel alloys deposited by welding, brazing, or metallizing, and hard intermetallic compounds deposited by plasma spray and by the detonation flame coating process. Specific areas of usefulness are given for the various surface materials. R. B. S.

A67-28000 *

THE INFLUENCE OF VARIOUS PHYSICAL PROPERTIES OF METALS ON THEIR FRICTION AND WEAR BEHAVIOR IN VACUUM.

Donald H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio).

(American Society for Metals, American Society for Testing and Materials, and Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers, National Metal Congress, Chicago, Ill., Oct. 31-Nov. 3, 1966, Paper.)
Metals Engineering Quarterly, vol. 7, May 1967, p. 44-53. 36 refs.
[For abstract see issue 03, page 428, Accession no. A67-13271]

A67-28001

HIGH-TEMPERATURE BEARING MATERIALS.

W. A. Glaeser (Battelle Memorial Institute, Structural Physics Div., Columbus, Ohio).

(American Society for Metals, American Society for Testing and Materials, and Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers, National Metal Congress, Chicago, Ill., Oct. 31-Nov. 3, 1966, Paper.)
Metals Engineering Quarterly, vol. 7, May 1967, p. 53-58. 9 refs.

Review of alloys, cermets, and ceramics used in bearing applications (both rolling contact and sliding) at temperatures from 600 to 2000°F. The significance of oxides in high-temperature bearing performance is discussed. Future requirements for high-temperature bearing materials are given. R. B. S.

A67-28147

STRESS CORROSION OF BERYLLIUM IN SYNTHETIC SEA WATER.

R. A. Miller (USAF, Office of Aerospace Research, Aerospace Research Laboratories, Wright-Patterson AFB, Ohio), J. R. Myers (USAF, Air University, Institute of Technology, Corrosion Research Laboratory, Wright-Patterson AFB, Ohio), and R. K. Saxer (U.S. Air Force Academy, Colorado Springs, Colo.).

Corrosion, vol. 23, Jan. 1967, p. 11-14. 5 refs.

Analysis of quantitative data on the continuous total immersion corrosion of pickled beryllium sheet material in synthetic sea water. It was revealed that the corrosion rate decreases asymptotically from about 21.5 to 2.0 mils/yr as the exposure period increased from 5 to 150 days. Beryllium was observed to be susceptible to severe pitting attack. Testing established that beryllium is susceptible to stress-corrosion when exposed to synthetic sea water. Time-to-failure decreased from about 2340 to 40 hr as the applied tensile stress was increased from 1220 to 40,000 psi. Electron fractography studies suggested that stress-corrosion failure occurred transgranularly. M. F.

A67-28148

HIGH TEMPERATURE CORROSION AND EVAPORATION OF HAYNES 25 AND HASTELLOY X-280.

L. A. Charlot and R. E. Westerman (Battelle Memorial Institute, Pacific Northwest Laboratory, Chemistry Dept., Richland, Wash.).

Corrosion, vol. 23, Feb. 1967, p. 50-56. 7 refs.
AEC Contract No. AT (45-1)-1830.

The corrosion behavior of Hastelloy X-280 and Haynes 25 at 1120°C in atmospheres of oxygen, carbon monoxide, carbon dioxide, water vapor and methane has been investigated. Evaporation rates of the superalloys in vacuo have been determined to 1200°C. Oxidation rates generally were found to increase with increasing pressure in the range 0.04 to 760 torr. Oxidation rates in other oxidants were less than those in pure oxygen. Thermal cycling reduced the oxidation resistance of Haynes 25. Both alloys carburize readily at 1120°C in a methane atmosphere. The carburization process can be reversed easily and ductility recovered by exposing material to oxidizing atmosphere at the same temperature. Evaporation of superalloys in vacuo at 1120°C can result in metal loss approximating that found under oxidizing conditions. Preformed oxide films are shown to be ineffective barriers to evaporation in an inert atmosphere (vacuum) at 1120°C. (Author)

A67-28257 #

BEHAVIOR OF A VIBRATION OF ONE DEGREE OF FREEDOM UNDER VIBRATING SOLID FRICTION OF HIGH FREQUENCY.

Genrokuro Nishimura, Yasuo Jimbo, and Masaharu Takano.

Tokyo, University, Faculty of Engineering, Journal, Series B, vol. 28, Sept. 1966, p. 303-364. 10 refs.

Theoretical analysis of design factors leading to the development of a long-period vibrometer of small size. The dynamic properties of vibrating solid friction for the case of high frequency and low amplitude are considered. Cases involving the resonance condition and with and without fluid friction are treated. M. F.

A67-28500 #

FUEL INJECTION SYSTEM USED ON AIRCRAFT ENGINES [SISTEMUL INJECŢIEI DE BENZINĂ FOLOSIT LA MOTOARELE DE AVION].

Mircea Buruiană.

Revista Transporturilor, vol. 14, Mar. 1967, p. 104-107.
In Rumanian.

Discussion of fuel-injection systems used for aircraft engines, dealing with the disadvantages of internal combustion engines, general layout of a fuel-injection system, control of a fuel-injection engine, and advantages and disadvantages of a fuel-injection system. The seriousness of the corrosion and impurity-prevention problems in the fuel-injection system is stressed. M. M.

A67-28783

EFFECT OF ELECTRICAL CURRENTS ON BALL BEARING DAMAGE IN VACUUM AND IN AIR.

S. F. Murray and P. Lewis (Mechanical Technology, Inc., Latham, N.Y.).

American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Preprint 67AM 1C-1. 10 p.
Members, $0.75; nonmembers, $1.50.

A brief experimental study based upon an application requirement was made to determine the effect of stray electrical currents on the damage of lightly loaded, oil-lubricated ball bearings operating at 7 rpm in vacuum and in air. Type 52100 steel bearings were run for 120 hr in vacuum at 10^{-7} mm Hg. Both 52100 steel and type 440C stainless steel bearings were run for shorter periods of time in air. A chlorinated methylphenyl silicone oil was used as the lubricant in all of these tests. Microscopic pitting damage was observed on the 52100 steel bearings in both air and vacuum, even at currents as low as 0.167 amp. However, the type 440C bearings, which were only run in air, showed corrosion films rather than pitting damage. Based on a very limited number of tests, it is hypothesized that the damage observed may be influenced by electrochemical effects rather than being purely electrical in nature. (Author)

A67-28784

ON COMPETING FAILURE MODES IN ROLLING CONTACT.

T. E. Tallian (SKF Industries, Inc., Research Laboratory, King of Prussia, Pa.).

American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Preprint 67AM 1C-3. 68 p. 33 refs.
Members, $0.75; nonmembers, $1.50.
Navy-sponsored research.

Rolling contact failures are classified according to their failure mode as (1) wear, (2) plastic flow, (3) fatigue, and (4) bulk failures, with the last class arising outside the immediate contact area. The wear failures are subdivided into mild wear by loose particle removal and smearing involving metal transfer. Plastic failures may arise due to overload or to temperature imbalance. Fatigue is of the spalling or the surface-distress type. An analysis of the stress conditions in a rolling contact is sketched, taking into account stepwise refinements of the contact model, starting from Hertz theory, and progressively including surface traction, plasticity, elastohydrodynamic lubricant films, surface microtopography and the inhomogeneities of real metals. Each failure mode is associated with the relevant severity parameters of the contact stress condition, and a description of its mode of formation is given. Guidelines are provided for the identification of that failure mode which, among competing modes, is most likely to render a rolling contact inoperative in a given operating environment. (Author)

A67-28785

SUBMICRON BORON NITRIDE AS A GREASE THICKENER. II.

J. F. Ditter (Space-General Corp., El Monte, Calif.), R. D. Allen (Douglas Aircraft Co., Inc., Santa Monica, Calif.), H. T. Thomas (Wesleyan University, Middletown, Conn.), M. Gerstein (Marshall Industries, Dynamic Science Corp., Monrovia, Calif.), and J. B. Christian (USAF, Wright-Patterson AFB, Ohio).

American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Preprint 67AM 2C-2. 7 p. 5 refs.
Members, $0.75; nonmembers, $1.50.

Capillary rheometry data were obtained on greases prepared from silicone, 6-phenylether, and perfluoro-polymer base stocks thickened with submicron boron nitride powder. The perfluoro-polymer grease was subjected to 10,000 rpm Pope Spindle tests, with the following performance lifetimes: 2432 hr at 400°F, 1265 hr at 450°F, and 320 hr at 500°F. Four-ball wear tests also indicated excellent wear characteristics. (Author)

A67-28786

THE FRICTIONAL BEHAVIOR OF SOLID LUBRICANTS AT LOW SPEEDS.

J. R. Jones (Hughes Aircraft Co., Culver City, Calif.).

American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Preprint 67AM 5A-2. 8 p.
9 refs.
Members, $0.75; nonmembers, $1.50.
Research sponsored by the Hughes Aircraft Co.

The frictional behavior of solid lubricants was studied in press-fit tests using an electronic compression tester to measure and record friction as a function of time. Particular attention was given to molybdenum disulfide. A previous study of the effect of idle time on static friction is extended to higher speeds and to the second motions of specimens held in contact for long periods. Several recently developed powders are compared with molybdenum disulfide under the same conditions of sliding speed, load, and surface roughness. Data are presented relating coefficient of friction to surface roughness, speed, and history. MoS_2 is shown to be superior to the other powders as a lubricant for press-fit operations. Several conclusions are drawn, and some question is raised with respect to recent explanations for the effects of load and speed on frictional behavior. (Author)

A67-28787

WEAR COEFFICIENT CORRELATION OF TEST METHODS AND DESIGN CALCULATIONS FOR SOLID FILM LUBRICANTS.

Charles E. Haines and Charles W. Dufur (Boeing Co., Seattle, Wash.).

American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Preprint 67AM 5A-5. 37 p.
6 refs.
Members, $0.75; nonmembers, $1.50.

This paper presents a portion of the work done by the authors in developing a new approach to evaluation techniques for wear of solid film lubricants. The theory and experimental requirements are presented that are necessary to adapt the use of "wear coefficient" to the extremely thin films required for these materials. A method for correlation of wear data obtained on various testers is included. Experimental results have covered an environmental temperature range from -320 to 1100°F. Design formulas for linear motion, journal, thrust, and spherical bearings have been derived to utilize experimental data in the estimation of hardware bearing wear. (Author)

A67-28789

DEVELOPMENT OF POLYIMIDE BONDED SOLID LUBRICANTS.

M. Campbell and V. Hopkins (Midwest Research Institute, Kansas City, Mo.).

American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Preprint 67AM 7A-1. 9 p. 7 refs.
Members, $0.75; nonmembers, $1.50.

Results of work conducted to develop two heat resistant, organically bonded solid film lubricants are summarized. These solid film lubricants are composed of molybdenum disulfide, antimony trioxide, and thermosetting polyimide resins. The approach taken to develop these films is presented. Procedures followed to mix, apply, and cure these films are outlined. Equipment used to test solid film lubricants is described, and the test procedures followed are given. Wear lives obtained for the polyimide bonded films are presented and compared to those obtained for two inorganically bonded films, MLF-5 and MLF-9 at temperatures to 700°F as well as over a range of loads. It was concluded that one of the polyimide bonded films is superior to the MLF-5 and MLF-9 films to 600°F in air. Both of the polyimide bonded films exhibited usable wear life to 700°F in air and 1000°F in vacuum. At room temperature, one of the polyimide films, MLR-2, has exceptionally long wear life, superior to any film ever tested by the authors. (Author)

A67-28790

WEAR-LIFE IMPROVEMENT OF A SOLID FILM LUBRICANT.

B. D. McConnell, L. E. Wieser (USAF, Wright-Patterson AFB, Ohio), and K. R. Mecklenburg (Midwest Research Institute, Kansas City, Mo.).

American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Preprint 67AM 7A-2. 11 p.
25 refs.
Members, $0.75; nonmembers, $1.50.

Solid film lubricants exhibit a wear-in behavior, in which excess material is discarded as wear debris. The resulting compacted film provides the majority of the wear life of the film. One ceramic-bonded, sprayed film was investigated to determine if mechanical compression or if artificial filling of the film voids would improve the wear life. The particular film composition and preparation are presented, including the effects of specimen pretreatment upon wear-life improvement. Wear life and friction results are given for two methods of mechanical compression - sliding and rolling - and a double deposition technique, involving spraying and electrophoretic deposition. It was found that the double deposition film produced a lubricant system that had a wear life of over four million stress cycles on an opposed rub shoe machine which subjected specimens to a 25-lb normal load and a rubbing speed of 215 ft/min. (Author)

A67-28791

AN APPLICATION OF SELF-LUBRICATED COMPOSITE MATERIALS.

H. Halliwell, G. L. Thomas, J. R. Ward, and H. J. Skruch (U.S. Naval Material Command, Ship Research and Development Center, Marine Engineering Laboratory, Annapolis, Md.).

American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Preprint 67AM 7A-3. 11 p.
Members, $0.75; nonmembers, $1.50.

In a continuing program to exploit the unusual properties and potential advantages of solid composite lubricants, a sleeve-type seal based on reinforced polytetrafluoroethylene was developed as a piston seal for high-pressure air compressors. The status of the material development for maximizing the effectiveness and life of this seal is reported. Specifically considered is the use of an organized metallic filament-winding technique to provide a superior

reinforcing matrix as compared to the randomly dispersed particles and fibers used heretofore. New approaches to combinations of composites for this and other applications have been uncovered. It is possible to expect reliable compressor operation at 5000 psi using such seals in place of conventional split rings for periods beyond 1000 hr with very low rates of wear and air leakage. (Author)

A67-28792
PLASMA SPRAYING - A NEW METHOD OF APPLYING SOLID FILM LUBRICANTS.
V. Hopkins, R. Hubbell (Midwest Research Institute, Kansas City, Mo.), and R. Kremith (Giannini Scientific Corp., Amityville, N.Y.).
American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Preprint 67AM 7A-4. 9 p.
Members, $0.75; nonmembers, $1.50.
Contract No. AF 33(657)-10384.

Results of an investigation to determine the feasibility of applying solid lubricant films with a plasma spray gun. The gun configurations used to apply metal, resin, and ceramic bonded solid lubricant films are described. Results of friction and wear tests made on films are reported. The friction and wear equipment is described, and test procedures are given. The importance of gun configuration in avoiding lubricant degradation and/or dissociation as well as obtaining good binder fusion is delineated. A dual port entry gun which introduced binders in the hot zone and lubricants in a cool zone of the gun was found to be the best for applying metal and ceramic bonded MoS_2 type films. (Author)

A67-28793
LUBRICATION OF SUPERSONIC AIRCRAFT.
L. C. Lipp (Boeing Co., Seattle, Wash.).
American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Preprint 67AM 8A-1. 17 p.
Members, $0.75; nonmembers, $1.50.

Description of tests made with lubricants to be used on supersonic aircraft. Supersonic aircraft are exposed to temperatures above 450°F and require lubricants adapted to such heat. The test equipment used for their evaluation is capable of testing rolling element bearings at a temperature of 1200°F. This type of evaluation apparatus is simulative of airframe control bearings. For this purpose, a grease must be able to maintain a lubricant film, even though the oscillatory motions tend to push grease away from the loaded areas. Evaporation tests were conducted at 450°F to obtain an indication of the thermal stability of the greases under study. Some lubricants suitable for use at the elevated temperatures to be encountered by supersonic aircraft have been obtained, but there exists a need for further lubrication development. P.v.T.

A67-28794
OXIDATION-CORROSION CHARACTERISTICS OF AIRCRAFT TURBINE ENGINE LUBRICANTS.
J. P. Cuellar and B. B. Baber (Southwest Research Institute, San Antonio, Tex.).
American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Preprint 67AM 8A-2. 38 p.
Members, $0.75; nonmembers, $1.50.
Contracts No. AF 33(657)-11028; No. AF 33(615)-2384.

Apparatus and test procedures are described for the evaluation of the oxidation-corrosion characteristics of synthetic lubricants at elevated temperatures. Employing an 18-hr test procedure, screening test data are presented for eight lubricants covering a temperature range of 425 to 575°F, where lubricant capability permitted. The effects of moist test air and varying temperature are demonstrated for several MIL-L-9236 type and experimental type lubricants in the 18-hr test. Results are also given for a 5P4E polyphenyl ether using varied test conditions of temperature, metal specimens, air flow, nitrogen-air mixtures, and reflux of condensable vapors. Similar but less extensive studies are described for several other advanced oil formulations. (Author)

A67-28796
PERFLUORINATED LUBRICANTS FOR LIQUID FUELED ROCKET MOTOR SYSTEMS.
Joseph Messina (U.S. Army, Frankford Arsenal, Philadelphia, Pa.).
American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Preprint 67AM 8A-4. 6 p.
18 refs.
Members, $0.75; nonmembers, $1.50.

Perfluoro hydrocarbon polymer oils and grease mixtures of these oils prepared with a low molecular weight (10,000-50,000) polytetrafluoroethylene thickener were studied in connection with the development of lubricants compatible (insoluble and inert) with liquid-fueled rocket engine systems. Data are given which show that the polymer oils and grease mixtures are nonreactive with conventional fuels and oxidizers, exhibit adequate lubricating and anti-seize properties, extremely low vapor pressures, no effect on conventional elastomers, nonexplosiveness at high shear and high loads with metal combinations, and nonsensitivity at high impact energies with oxidizers. The results indicate that the oils and greases discussed are promising lubricants for rocket motor systems. (Author)

A67-28822
CLEANING BY SURFACE DISPLACEMENT OF WATER AND OILS.
H. R. Baker, P. B. Leach, C. R. Singleterry, and W. A. Zisman (U.S. Navy, Office of Naval Research, Naval Research Laboratory, Chemistry Div., Washington, D.C.).
I & EC - Industrial and Engineering Chemistry, vol. 59, June 1967, p. 29-40. 35 refs.

Simplified method of maintaining and renewing complex electrical and electronic equipment with the aid of basic surface chemistry. The theoretical aspects of surface chemistry and the mechanisms of water and oil displacement are discussed. Various water- and oil-displacing compositions are described, with attention to effects on electrical insulation. Some proved methods for restoring damaged equipment to use are described. F.R.L.

A67-28866 #
EVALUATING MECHANICAL AND CORROSION SUITABILITY OF MATERIALS.
B. F. Brown (U.S. Navy, Office of Naval Research, Naval Research Laboratory, Metallurgy Div., Washington, D.C.) and R. J. Goode (U.S. Navy, Office of Naval Research, Naval Research Laboratory, Strength of Metal Branch, Washington, D.C.).
American Society of Mechanical Engineers, Design Engineering Conference and Show, New York, N.Y., May 15-18, 1967, Paper 67-DE-7. 11 p. 7 refs.
Members, $0.75; nonmembers, $1.50.

Description of recently developed concepts and methods for characterizing fracture toughness, corrosion response, and low-cycle fatigue characteristics of the new high-strength metals in full thicknesses and for translating the results of predictions of structural performance. It is pointed out that these characteristics of advanced high-strength metals are of critical importance in structural design and materials selection for present and future high-performance structures. The methods for evaluating these materials and for application of the results to predicting structural performance are not widely understood. M.M.

A67-28873 #
INFRARED OPTICS FOR EVALUATING DYNAMIC MECHANICAL COMPONENTS.
William J. Quinn (Hughes Aircraft Co., Research and Development Div., Culver City, Calif.).
American Society of Mechanical Engineers, Design Engineering Conference and Show, New York, N.Y., May 15-18, 1967, Paper 67-DE-24. 6 p. 5 refs.
Members, $0.75; nonmembers, $1.50.

The use of completely passive infrared optic techniques for determining the thermal characteristics of dynamic components is being investigated. Studies are being performed with an induction motor (11,250 rpm max) and a low-speed (40 rpm max) bearing test fixture. When combined with other advanced techniques, such as

electrical-discharge machining, the capabilities of infrared instruments will provide the ability to perform fundamental work in studyir metal fatigue and wear and friction phenomena. (Author)

A67-29004
STUDY OF THE EFFECTS OF ROTOR BEARING CLEARANCE ON THE WHIRLING OF A GIMBAL-MOUNTED GYROSCOPE.
J. N. Fawcett (Newcastle-upon-Tyne, University, Dept. of Mechanical Engineering, Newcastle-upon-Tyne, England) and H. McCallion (Nottingham University, Dept. of Mechanical Engineering, Nottingham, England).
Journal of Mechanical Engineering Science, vol. 9, Apr. 1967, p. 138-148. 5 refs.
Research supported by the Department of Scientific and Industrial Research.

Study of the effects of varying the gimbal inertia and bearing clearance on the motion of the rotor shaft of a gyroscope within its bearings during whirling and on the stability of the gyroscope system. The analysis is limited to gyroscopes in which the rotor shaft runs in ball races. The design of an experimental facility which represents the simplest possible system is described, and a theory based on the experimentally observed behavior of the rotor shaft within the bearing is outlined. The theoretically predicted effects of varying the bearing clearance are shown to have trends similar to the observed behavior for the cases considered. B.B.

A67-29261
LIQUIDUS CURVES AND CORROSION OF Fe, Cr, Ni, Co, V, Cb, Ta, Ti, Zr, IN 500-750 C MERCURY.
John R. Weeks (Brookhaven National Laboratory, Upton, N.Y.).
National Association of Corrosion Engineers, Conference, 20th, Chicago, Ill., Mar. 9-13, 1964, Paper.)
Corrosion, vol. 23, Apr. 1967, p. 98-106. 9 refs.
AEC-sponsored research.

Liquidus curves of Fe, Cr, Ni, Co, V, Cb, Ta, Ti and Zr with Hg have been investigated at temperatures from 500 to 750°C. From the results, relative corrosion rates have been estimated for each of these pure metals at 600°C in Hg which is saturated at 600°C. Predicted corrosion rates increase in the sequence: Ta, Cb, Fe, Co, V, Cr, Zr, Ti, Ni. A stress-sensitive penetration of grain boundaries of Cb-1Zr by Hg was shown to be associated with selective leaching of Zr from the alloy. Annealing the alloy before stressing it reduced but did not eliminate this attack. (Author)

A67-29457
HOW RELIABLE ARE PLASTIC ENCAPSULATED TRANSISTORS?
Motorola Monitor, vol. 5, no. 1, 1967, p. 12-15.

Discussion of the results of reliability tests of plastic encapsulated transistors. A summary of the results demonstrates that these plastic encapsulated devices retain the high performance level associated with similar chips housed in hermetically sealed packages with respect to life tests and that they meet or exceed military requirements from an environmental and mechanical standpoint. Lifetest acceptance criteria show that the encapsulated transistor data rivals those of metal-package devices. Results of thermal and mechanical-stress and moisture-resistance tests are given. Even under the extremes of the accelerated thermal-shock test, parameter shift results were excellent, with no catastrophic failures. M.F.

A67-29558 *
EVALUATION OF VARIOUS LUBRICATION METHODS AT ORBITAL CONDITIONS FOR SPACE VEHICLES.
C. B. Kollmansberger (McDonnell Co., St. Louis, Mo.).
IN: THE EFFECTS OF THE SPACE ENVIRONMENT ON MATERIALS; SOCIETY OF AEROSPACE MATERIAL AND PROCESS ENGINEERS, NATIONAL SYMPOSIUM AND EXHIBIT, 11TH, ST. LOUIS, MO., APRIL 19-21, 1967, PROCEEDINGS. [A67-29534 15-18]
North Hollywood, Calif., Western Periodicals Co. (Science of Advanced Materials and Process Engineering Series. Volume 11), 1967, p. 257-263.
Contract No. NAS 9-170.

Evaluation of various methods of lubrication for space vehicle mechanisms. A test apparatus had to be designed and built to test lubricants at ultrahigh vacuum, high bearing loads, a wide temperature range, and low speed. Data have been generated on organic and inorganic bonded solid film lubricants, metal plating systems, plastic bearing materials, and greases. The results of the tests indicate that a silicate bonded solid film lubricant pigmented with MoS_2 and graphite is the best lubricant. At high-temperature ester type grease had the best properties of the greases tested. The data indicate that the orbital environment has a pronounced effect on most lubrication methods when the results are compared to their performance at atmospheric pressure. P.v.T.

A67-29671
REINFORCED PLASTICS FOR JET LIFT ENGINES.
H. E. Gresham and C. G. Hannah (Rolls-Royce, Ltd., Derby, England).
(Royal Aeronautical Society, Specialist Lecture, Feb. 9, 1967.)
Royal Aeronautical Society, Journal, vol. 71, May 1967, p. 355-362; Discussion, p. 362-365.

Discussion of the use of reinforced plastics composites for the RB 162 compressor. These materials were used because they satisfy the initial weight and cost requirements and because of their high order of fatigue and corrosion resistance. Considerable use has been made of epoxy resin preimpregnated sheets aligned with glass fiber. Factors influencing the choice of resin systems are discussed, and characteristics of parallel strand materials revealed by mechanical tests are reviewed. The most rewarding properties of these materials are absence of true creep, high internal damping, and slow progressive noncatastrophic mode of failure. These properties result in long fatigue life and elimination of blade containment problems. M.F.

A67-29827
THE ROLE OF CLADDING IN THE FATIGUE OF DURALUMIN.
A. V. Karlashov, V. P. Tokarev, and A. P. Batov (Kievskii Institut Grazhdanskogo Vozdushnogo Flota, Kiev, Ukrainian SSR).
(Fiziko-Khimicheskaia Mekhanika Materialov, vol. 1, Nov.-Dec. 1965, p. 707-711.)
Soviet Materials Science, vol. 1, Nov.-Dec. 1965, p. 483-486. 6 refs. Translation.

Results of a study of fatigue damage suffered by clad and unclad aluminum alloy D16 (Duralumin) used in aircraft and in aircraft components with large surface areas and relatively small thicknesses. It is shown that cladding affects the fatigue and corrosion-fatigue strength of alloy D16 causing a substantial reduction in the fatigue strength of the alloy in air; that the degree of protection offered by the cladding material against corrosion by ambient media is reduced by alternating stresses; and that residual compressive stresses are set up in the cladding layer. P.v.T.

A67-29973
NIOBIUM SPRING ALLOY WITH A STABLE ELASTIC MODULUS AT HIGH TEMPERATURES.
A. K. Borisova and B. G. Belov (Tsentral'nyi Nauchno-Issledovatel'skii Institut Chernoi Metallurgii, Moscow, USSR).
(Metallovedenie i Termicheskaia Obrabotka Metallov, June 1966, p. 10, 11.)
Metal Science and Heat Treatment, May-June 1966, p. 441-443. Translation.
[For abstract see issue 20, page 3583, Accession no. A66-37366]

A67-30149 * #
MICROSLIPS BETWEEN CONTACTING PARABOLOIDS.
V. C. Mow, P. L. Chow, and F. F. Ling (Rensselaer Polytechnic Institute, Dept. of Mechanics, Troy, N.Y.).
American Society of Mechanical Engineers, Applied Mechanics Conference, Pasadena, Calif., June 26-28, 1967, Paper 67-APM-12. 8 p. 7 refs.
Contract No. NAS 3-7629.

Generalization of a Hertz problem and a Mindlin problem for fourth-order paraboloids in contact. Microslips and annulus of slip are especially sought, an inverse method being devised for this purpose. An optimization procedure is described for finding the geometry for a given loading condition and a set of material properties within the family of paraboloids which gives minimum slip. An example is given to show that the annulus of slip can be reduced by 60%, while maximum slip can be reduced by 90%. B.B.

A67-30853 #

FACTORS AFFECTING THE ENDURANCE OF RUBBED LUBRICANT FILMS OF LAMELLAR SOLIDS.

J. P. Giltrow (Ministry of Technology, Royal Aircraft Establishment, Chemistry, Physics and Metallurgy Dept., Farnborough, Hants., England).

British Journal of Applied Physics, vol. 18, June 1967, p. 831-838. 10 refs.

Experiments have been carried out, using a pin and disk machine, to measure the influence of surface roughness and humidity on the endurance of rubbed films of several lamellar solids on steel. An environment of high relative humidity during film formation leads to enhanced endurance, while high humidity during film testing leads to reduced endurance. The coefficients of friction increase with increasing relative humidity of the environment. An optimum film life is exhibited on substrates of roughness approximately 30-40 μin. CLA (center-line average). It is tentatively suggested that the inability of group V_A metal dichalcogenides to lubricate steel may be due to their lack of crystalline order, resulting either from their probable nonstoichiometric composition or from inherent turbostraticity in the crystal. (Author)

A67-31021

FRICTION AND WEAR OF POLYMERS REINFORCED WITH CARBON FIBRES.

J. P. Giltrow and J. K. Lancaster (Ministry of Technology, Royal Aircraft Establishment, Farnborough, Hants., England).

Nature, vol. 214, June 10, 1967, p. 1106, 1107.

Examination of the friction and wear properties of a variety of resins and polymers reinforced with carbon fibers. Composites with thermoplastics were prepared by blending chopped carbon fibers with a water dispersion of the powdered polymer in a liquidizer; the mixture was then dried and compression molded into a bar. For the thermosetting resin composites, the liquid resin was poured over a random mat of fibers in a mold and light pressure applied during curing. The coefficient of friction and the rate of wear of each composite were determined on a crossed-cylinders wear machine. All experiments were made in dry conditions of sliding. The wear rates of various polymers with and without reinforcement by 30% weight of high modulus carbon fiber are compared, and the effect of varying the amount of carbon fiber reinforcement on the wear rate, friction and ultimate flexural strength of polytetrafluoroethylene is shown. R.B.S.

A67-31369

FATIGUE OF AN ALUMINUM ALLOY IN ULTRAHIGH VACUUM AND AIR.

Joseph M. Jacisin (Bell Telephone Laboratories, Inc., Whippany, N.J.).

AIME, Transactions, vol. 239, June 1967, p. 821-823. 6 refs.

Fatigue tests were conducted on 2017-T4 aluminum alloy in an ultrahigh vacuum of 2×10^{-10} torr and in air. The ratio of vacuum-to-air fatigue life for this material varied from 3.5:1 at a strain of 2.5×10^{-3} in. per in. to 8:1 at a strain of 3.3×10^{-3} in. per in. Some preliminary data were also obtained on the fatigue life of the aluminum alloy in a dry-nitrogen atmosphere. A dark deposit observed on the fracture surfaces of the air-tested specimens was identified as oxides of manganese and magnesium. This observation, and the close correlation between results obtained in vacuum and dry-nitrogen environments, tend to confirm that air strongly influences the fatigue mechanism by a corrosion process. (Author)

A67-31382 #

THE MAGNETORHEOSTATIC BEARING AND MAGNETORHEODYNAMIC SQUEEZE FILM.

J. B. Shukla (Institute of Higher Technology, Dept. of Mathematics, Kanpur, India) and R. Prasad (V.S. Sanatan Dharam College, Kanpur, India).

American Society of Mechanical Engineers, Lubrication Symposium, Miami Beach, Fla., June 4-7, 1967, Paper 67-Lubs-4. 8 p. 10 refs.

Members, $0.75; nonmembers, $1.50.

The paper discusses the use of conducting Bingham plastic fluids as lubricants in a rheostatic bearing in the presence of a constant axial magnetic field. It is shown that the load capacity increases as the magnetic Hartmann number increases for a constant flux. The magnetorheodynamic squeeze film between two circular plates is also studied and it is observed that the time of approach increases as the Hartmann number increases. In both the foregoing cases, the effects of magnetic field and yield stress on the extent of the plug are investigated. It is observed that the extent of the core slowly increases as strength of the magnetic field increases. (Author)

A67-31384

ROLE OF SLIP STEP EMERGENCE IN THE EARLY STAGES OF STRESS CORROSION CRACKING IN FACE CENTERED IRON-NICKEL-CHROMIUM ALLOYS.

T. J. Smith (Procter and Gamble, Cincinnati, Ohio) and R. W. Staehle (Ohio State University, Dept. of Metallurgical Engineering, Corrosion Center, Columbus, Ohio).

Corrosion, vol. 23, May 1967, p. 117-129. 22 refs.

AEC Contract No. AT (11-1)-1319.

Thin foils of four face-centered-cubic iron-nickel-chromium alloys and of pure iron and pure nickel have been examined in the electron microscope before and after exposure to boiling $MgCl_2$. Evidence of parallel dissolution arrays in stressed thin foils was taken as confirmation of formation of slip steps by dislocations which move while specimens are in intimate contact with an active environment. The faulted region exposes nonprotected base metal with the result that rapid local dissolution occurs along an axis of the active slip plane. Because parallel dissolution arrays occur in susceptible as well as nonsusceptible alloys, the process of slip step activated dissolution is taken to be necessary, but not critical in stress corrosion cracking. Evidence is presented to suggest that neither dislocation coplanarity (as shown in thin foils) nor dislocation reactivity are factors in stress corrosion cracking in austenitic Fe-Ni-Cr alloys. The emergent slip step model is hypothesized to be useful in interpreting propagation phenomena and grain size effects in stress corrosion cracking susceptibility. (Author)

A67-31385

STRESS CORROSION CRACKING OF HIGH STRENGTH STEELS AND TITANIUM ALLOYS IN CHLORIDE SOLUTIONS AT AMBIENT TEMPERATURE.

M. H. Peterson, B. F. Brown, R. L. Newbegin, and R. E. Groover (U.S. Navy, Office of Naval Research, Naval Research Laboratory, Metallurgy Div., Washington, D.C.).

(National Association of Corrosion Engineers, Conference, 22nd, Miami Beach, Fla., Apr. 18-22, 1966, Paper.)

Corrosion, vol. 23, May 1967, p. 142-148; Discussion, E. H. Phelps (U.S. Steel Corp., Applied Research Laboratory, Monroeville, Pa.) and W. L. Miller (U.S. Naval Material Command, Naval Applied Science Laboratory, Brooklyn, N.Y.), p. 148; Authors' Reply, p. 148. 7 refs.

By using a precracked cantilever-loaded test specimen, a relatively rapid and economical method of studying stress corrosion cracking (SCC) in chloride solutions was developed. The method permits testing sensitivity of specimens to SCC in a fraction of the time required for smooth specimens. Both high strength steels and titanium alloys proved susceptible in flowing sea water. AISI 4340 heat treated to strengths up 225 ksi showed stress intensity increasin as the crack grew. Stress cracking of Ti-8Al-1V occurred at a final velocity of 1/4 in./min. Cathodic protection of high strength steel was not found to be a reliable means of preventing SCC because of

close potential control required. At potentials created by a steel-zinc couple, it cracked at a stress intensity much lower than was the case for a freely corroding specimen. (Author)

A67-31420
THE FLOW OF A VISCOUS COMPRESSIBLE FLUID THROUGH A VERY NARROW GAP.
J. D. Cole, H. B. Keller, and P. G. Saffman (California Institute of Technology, Pasadena, Calif.).
SIAM Journal on Applied Mathematics, vol. 15, May 1967, p. 605-617.
NSF Grant No. GP-4597.

Study of the flow of a lubricant forced through a gap by a pressure gradient, based on work by Taylor and Saffman (1957). This previous work, concerning the effect of compressibility on the pressure distribution in the narrow gap between a rotating cylinder and a plane in a viscous fluid, was modified slightly to be of aid in the present work. Both forced flow and free flow cases were studied. R. B. S.

A67-31751
VARIATION OF FRICTION AND WEAR OF SOLID LUBRICANT FILMS WITH FILM THICKNESS.
Ernest Rabinowicz (Massachusetts Institute of Technology, Dept. of Mechanical Engineering, Cambridge, Mass.).
(American Society of Lubrication Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, Paper.)
ASLE Transactions, vol. 10, Jan. 1967, p. 1-6; Discussion, Vern Hopkins (Midwest Research Institute, Kansas City, Mo.), M. B. Peterson (Mechanical Technology, Inc., Latham, N.Y.), W. E. Campbell (Rensselaer Polytechnic Institute, Troy, N.Y.), and G. Salomon (Nederlandse Centrale Organisatie T.N.O., Centraal Laboratorium, T.N.O., Delft, Netherlands), p. 6-9; Author's Closure, p. 9. 19 refs.
Contract No. DA-31-124-ARO(D)-143.

For solid lubricant films such as oxides, soft metals and molybdenum disulfide in a resin, low friction and low wear have been found when the film thickness lies between 10^{-6} and 10^{-3} cm, and high friction and high wear outside these limits. At the 10^{-3}-cm limit, the rise in friction occurs because the load is carried by the film rather than by the substrate, while the rise in wear is caused by the formation of large wear particles. The experimental data appear to agree reasonably well with theoretical predictions based on the concepts of characteristic junction size and wear particle size. (Author)

A67-31752
UNIQUE SOLID LUBRICATING MATERIALS FOR HIGH TEMPERATURE-AIR APPLICATIONS.
D. J. Boes (Westinghouse Electric Corp., Atomic, Defense and Space Group, Research and Development Center, Research Laboratories, Pittsburgh, Pa.).
(American Society of Lubrication Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, Paper.)
ASLE Transactions, vol. 10, Jan. 1967, p. 19-26; Discussion, L. J. Bonis, H. L. Levingston (Ilikon Corp., Natick, Mass.), and Harold E. Sliney (NASA, Lewis Research Center, Cleveland, Ohio), p. 26, 27.

Development of a technique for obtaining self-lubricating bodies of high mechanical strength and oxidation resistance. By an "amalgamation" of powdered solid lubricants (such as tungsten diselenide) with a gallium alloy, followed by a subsequent compression-curing cycle, it proved possible to obtain self-lubricating surfaces resisting oxidation at temperatures as high as 1500°F. Friction-wear characteristics of such materials at temperatures up to 950°F are examined, showing the potential of the materials as load-bearing surfaces and seals in high-temperature applications for both oxidizing and inert or vacuum environments. V. P.

A67-31753
COMPRESSIVE AND TENSILE PROPERTIES OF MOLYBDENUM DISULFIDE COMPACTS.
J. C. Tyler and P. M. Ku (Southwest Research Institute, Dept. of Aerospace Propulsion Research, San Antonio, Tex.).
(American Society of Lubrication Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, Paper.)
ASLE Transactions, vol. 10, Jan. 1967, p. 28-34; Discussion, H. F. Barry (Climax Molybdenum Co., Ann Arbor, Mich.), Donald H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio), and Martin J. Devine (U.S. Naval Air Engineering Center, Aeronautical Materials Laboratory, Philadelphia, Pa.), p. 34-36; Authors' Closure, p. 36, 37.
Contract No. NOw-0545-f.

Compacts of molybdenum disulfide powder were made, without the use of a binder, over a wide range of compacting pressures and length-to-diameter ratios. Their specific gravity, hardness, and compressive and tensile properties were determined at approximately sea-level pressure and 75°F. The ultimate compressive strength and ultimate tensile strength were found to be essentially functions of specific gravity only, and the relationships are presented. The modulus of elasticity was found to be essentially the same in compression and in tension, and is also presented as a function of specific gravity. (Author)

A67-31754
THERMAL STABILITY CHARACTERISTICS OF SOME MINERAL OIL AND HYDROCARBON HYDRAULIC FLUIDS AND LUBRICANTS.
E. E. Klaus (Pennsylvania State University, Dept. of Chemical Engineering, Petroleum Refining Laboratory Div., University Park, Pa.) and J. M. Perez (Kendall Refining Co., Bradford, Pa.).
(American Society of Lubrication Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, Paper.)
ASLE Transactions, vol. 10, Jan. 1967, p. 38-47; Discussion, Neal W. Furby (Chevron Research Co., Richmond, Calif.) and H. F. Bieber (Pennsylvania State University, University Park, Pa.), p. 47. 14 refs.
Contract No. AF 33(657)-10374.

The thermal stability properties of n-hexadecane, superrefined mineral oils, and oligomers have been measured as a function of time and temperature. The versatility of the PRL pressure cylinder thermal stability test is demonstrated. Chromatographic techniques to provide quantitative data on the products of decomposition are described. The similarity in mechanism is shown for the thermal degradation of pure hydrocarbons and mineral oils, while distinctly different mechanisms are shown for mineral oils and oligomers. Differences in the thermal degradation reactions in the gas and liquid phases emphasize the need for close control of any standard long time thermal stability test because of secondary reactions involved. The large effects of small amounts of gas and volatile products formed on the measurements conventionally used to estimate thermal degradation are discussed. (Author)

A67-31755
OIL MIST DEPOSITS TEST - A TECHNIQUE FOR EVALUATING THE DEPOSIT FORMING TENDENCY OF JET ENGINE LUBRICANTS.
N. T. Bartholomaei (Texaco, Inc., Research and Technical Dept., Beacon, N.Y.), M. E. Massey (Texaco, Inc., Oil Stability Group, Beacon, N.Y.), and R. A. Holstedt (Texaco, Inc., Beacon, N.Y.).
(American Society of Lubrication Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, Paper.)
ASLE Transactions, vol. 10, Jan. 1967, p. 48-55; Discussion, C. W. Lawler (ALCOR, Inc., San Antonio, Tex.), p. 55, 56; Authors' Closure, p. 56, 57.

A hypothesis of the mechanism of the formation and growth of deposits from jet-engine lubricants in today's jet engines is discussed. Deposit formations are most often found in areas of the engines which are not flood-lubricated. Lubricant is transported as a spray or mist to hot static areas of the engine where deposits can form. The "oil mist deposits test," a laboratory technique which can be used to differentiate between the deposit-forming tendencies of lubricants, is presented. The results obtained by the laboratory technique are equated to levels of deposits found in field engines. (Author)

A67-31756
EP FILMS FROM BORATE LUBRICANTS.
K. L. Kreuz, R. S. Fein, and M. Dundy (Texaco, Inc., Research Center, Beacon, N.Y.).
(American Society of Lubrication Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, Paper.)
ASLE Transactions, vol. 10, Jan. 1967, p. 67-75; Discussion, Douglas Godfrey (Chevron Research Co., Richmond, Calif.), p. 75, 76; Authors' Closure, p. 76. 17 refs.

The EP (extreme pressure) films generated by borate-containing lubricants were studied to determine their structure and mode of action. Films were generated on SAE Machine test specimens with a blend of tribenzyl borate in solvent neutral oil. Study of the generated films in situ and after chemical stripping show them to be amorphous structures a few thousand angstroms thick containing boron, ferrous iron and organic components. Attempts to reproduce film material synthetically are described. Surfaces with borate EP films are shown to be harder than the steel substrate. Thus, they do not conform to the usual concept of more conventional EP agents which are generally believed to provide an easily-sheared film.
(Author)

A67-31816 * #
IMPORTANCE IN LUBRICATION OF VARIOUS INTERFACE TYPES FORMED DURING VACUUM DEPOSITION OF THIN METALLIC FILMS.
T. Spalvins and D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio).
American Vacuum Society, Vacuum Metallurgy Conference, 10th, New York, N.Y., June 13-15, 1967. 17 p. 10 refs.

Discussion of vacuum deposition methods used to deposit soft, thin-metal gold film on metal surfaces for lubrication purposes. The adhesion characteristics of the deposited metal film to the substrate depend on the type and structure of the interfacial region, which is directly related to the solid solubility and alloying concepts. Three vacuum deposition methods are used: (1) vapor deposition, (2) sputtering, and (3) ion plating. The characteristics of the film and interface were examined in friction experiments in ultrahigh vacuum. The coefficient of friction was used to determine the strength and durability of the deposited film. Depending on the vacuum deposition method and the selection of film and substrate materials, five types of interface can be distinguished. The diffusion and high-energy embedded interfaces are desirable, because a graded, layer-like interface is formed. P.v.T.

A67-31915
MEASURING COEFFICIENTS OF FRICTION IN SERVOVALVES.
P. R. Ukrainetz (Saskatchewan, University, Dept. of Mechanical Engineering, Saskatoon, Saskatchewan, Canada) and S. C. Tsai.
Hydraulics and Pneumatics, vol. 20, June 1967, p. 118-120.
Research supported by the National Research Council.

Derivation of equations which provide an accurate approximation of the viscous friction existing in the spool and nozzle-flapper pre-amplifier stages of an electrohydraulic servovalve. Knowing the mass of the spool, the spring constant of one restraining spring, and the angular frequency of the exciting force, and measuring the phase angle, it is possible to calculate the value of the viscous damping coefficient. Methods for measuring the phase angle under various excitation frequencies are proposed. V.P.

A67-32263
ROLLING FRICTION WITH AXIAL THRUST [ROLLREIBUNG MIT AXIALEM SCHUB].
G. Heinrich and K. Desoyer (Wien, Technische Hochschule, Vienna, Austria).
Ingenieur-Archiv, vol. 36, no. 1, 1967, p. 48-72. 5 refs. In German.

Investigation by means of first-order elasticity theory of the problem of an elastic cylinder of circular cross section moving obliquely on the surface of an elastic half-space. It is assumed that Coulomb's law of friction is valid for each element of the contact area. After the derivation of the nonlinear singular integral equations governing this problem, methods for a numerical solution for the case of equal material constants are presented. For a Poisson's ratio of 0.3 (steel on steel) the complete range of possible solutions is given and shown in graphs. P.v.T.

A67-32824
HOW TO PREVENT FATIGUE FAILURE. II.
Robert E. Little (Michigan, University, Dearborn, Mich.).
Machine Design, vol. 39, July 6, 1967, p. 130-137.

Discussion of methods for increasing the strength of a part or system to prevent fatigue failure. The methods discussed include increasing bulk strength, increasing local strength, eliminating fretting, scoring, and corrosion, eliminating sharp corners, improving the surface finish, and improving ductility and impact strength. M.F.

A67-32989
A NEW CONCEPT FOR CRITICAL SPEED CONTROL.
M. Kulina, J. Mullen, M. Natesh, and H. Saltzman (Curtiss-Wright Corp., Wright Aeronautical Div., Wood-Ridge, N.J.).
Society of Automotive Engineers, National Aeronautic Meeting, New York, N.Y., Apr. 24-27, 1967, Paper 670347. 37 p. 9 refs.
Members, $0.75; nonmembers, $1.00.

Description of a device for the control of critical speeds, consisting of a squeeze-film oil damper between two nonrotating parts in parallel with a flexible bearing support. A mathematical model of the vibratory system is developed, showing the existence of two different critical speeds as a function of damping. From the model, the response of the system is predicted. A critical-speed test rig was designed and fabricated, and a test program was conducted. The results of the experimental investigation confirm the applicability of the model and the use of the device as a critical-speed control. Further testing is reported on the effect of various design parameters on damping, and a simple method of varying the damping on the test stand during engine operation is shown. The results of the investigation were applied to the design of a similar device for a multistage compressor which was successfully operated with low amplitude throughout the speed range. Disassembly following 150 hours of compressor testing showed all parts to be in excellent condition.
R.B.S.

A67-33002
OPERATION OF THE GE T64 ON EMULSIFIED FUEL.
William J. Crawford, III (General Electric Co., Flight Propulsion Div., West Lynn, Mass.).
Society of Automotive Engineers, National Aeronautic Meeting, New York, N.Y., Apr. 24-27, 1967, Paper 670369. 6 p.
Members, $0.75; nonmembers, $1.00.

Based upon initial testing, it was concluded that the T64 engine could operate on emulsified fuel (JDI) without any engine or control adjustment or modifications. This was accomplished without loss of performance or deterioration of engine components. However, the limited program indicated that water additives had severe effects on fuel system components which meet normal Military Specification corrosion resistance requirements. Extensive follow-on testing for fuels and long-term engine endurance operation are required to evaluate these fuels fully from an engine life standpoint. The paper summarizes engine operation, and describes components following limited operation on a water emulsification of JP4.
(Author)

A67-33048
EVALUATING ALLOYS FOR FAILURE-SAFE STRUCTURES.
Robert J. Goode (U.S. Navy, Office of Naval Research, Naval Research Laboratory, Metallurgy Div., Strength of Metals Branch, Washington, D.C.).
Metal Progress, vol. 92, July 1967, p. 95-100, 102, 104.

Determination of the fracture toughness, fatigue strength, and resistance to stress-corrosion cracking in alloys for failure-safe

structures. Explosion tear tests are shown to confirm that most steels above 200,000 psi yield strength lie in regions where brittle fracture should be expected; also indicated is that many of the conventional steels with yield strengths of 180,000 to 220,000 psi are also characterized by low resistance to fracture. The tests described have one important feature in common; all specimens contain cracks or flaws. As such, they give information about the growth of fractures, an important consideration in large welded structures. Because such structures have complex forms, failure-safe application of materials in them requires that plastic strains be attainable before crack growth will occur. Thus these tests have a broad use for studying structural materials. R.B.S.

A67-33049
A MARAGING STAINLESS FOR 800 TO 1100°F SERVICE.
Robert L. Caton (Carpenter Steel Co., Reading, Pa.).
Metal Progress, vol. 92, July 1967, p. 106-108.

Introduction of a stainless steel designated as Pyromet X-15, which combines corrosion resistance comparable to that of types 410 and 430 stainless steels and usable strength in the 800 to 1100°F range. The heat treatment and properties of the steel are discussed, and comparisons with other alloys are given. Pyromet X-15 is generally cold-worked in the solution-treated condition. Because its rate of work hardening is low, the alloy can be reduced as much as 80% without intermediate anneals. The alloy is normally machined in the solution-treated condition. Weld characteristics are also mentioned. R.B.S.

A67-33169
ANTIFRICTION PROPERTIES OF SOME COMPOSITE SINTERED PACKING MATERIALS. II.
M. E. Belitskii (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukrainian SSR).
(Poroshkovaia Metallurgiia, vol. 6, Sept. 1966, p. 61-66.)
Soviet Powder Metallurgy and Metal Ceramics, Sept. 1966, p. 726-729. Translation.
[For abstract see issue 01, page 81, Accession no. A67-11246]

A67-33487 #
THE ROLE OF YIELDING IN STRESS-CORROSION CRACKING.
J. C. Scully (Leeds University, Dept. of Metallurgy, Leeds, England).
IN: PHYSICAL BASIS OF YIELD AND FRACTURE; OXFORD, ENGLAND, SEPTEMBER 28-30, 1966, CONFERENCE PROCEEDINGS. [A67-33481 18-17]
Edited by A. C. Stickland.
London, Institute of Physics and Physical Society (Institute of Physics and Physical Society Conference Series, No. 1), 1966, p. 119-124; Discussion, U. Lindborg and P. G. Partridge, p. 286, 287. 16 refs.

Detailed study of the role of yielding in producing dislocations in crack-susceptible alloys of pronounced chemical reactivity. Yielding in alloys which do not readily cross-slip causes considerable shear strain, which prevents the formation of a protective film at the tip of a crack, promotes electrochemical reactions by creating turbulent conditions near the tip and by causing segregational effects within the alloy lattice, and may also increase the aggressiveness of the corrodent through preferential adsorption on newly created slip steps. The main overall effect of yielding during stress-corrosion cracking is to produce a very highly localized high shear-strain rate along the plane on which the crack forms. Since susceptible alloys plastically deform on a comparatively small number of planes compared with alloys which cross-slip, the shear strain on slip planes in these alloys will be large. P. v. T.

A67-33661
DYNAMIC EFFECTS OF MOVING LOADS ON BEAMS [DINAMICHESKOE VOZDEISTVIE PODVIZHNYKH NAGRUZOK NA STERZHNI].
A. P. Filippov and S. S. Kokhmaniuk.
Kiev, Izdatel'stvo Naukova Dumka, 1967. 134 p. In Russian.

This book deals with the effects of moving loads on the stresses and strains in beams supported by linear and nonlinear bearings, as well as in beams lying on an elastic base. The results of investigations made on single - and multiple-span beams are given, and the coefficients of the stress and strain dynamics are determined for a number of spans. A complex contact problem of the three-dimensional theory of elasticity is considered for the case where a beam rests on an elastic half-space and forces or masses are moving along it. P.v.T.

A67-33994 #
CAUSES OF THE VARIATION IN VIBRATION LEVEL OF GYROMOTORS [O PRICHINAKH IZMENENIIA UROVNIA VIBRATSII GIROMOTOROV].
I. A. Baranov (Moskovskii Aviatsionnyi Tekhnologicheskii Institut, Moscow, USSR).
Priborostroenie, vol. 10, no. 5, 1967, p. 95, 96. In Russian.

Investigation of gyromotors, showing that there exist two main causes of the variations in their vibration level: (1) the geometrical and physical qualities obtained in manufacturing balls for ball bearings; (2) the technical conditions of running in gyromotors. Two ball rotation regimes are found to lead to a stabilization of gyromotor vibrations: (1) the rotating of a ball around one and the same axis - i.e., the wear trace must always be in the zone of contact; (2) a periodic change of the axis of rotation, producing an even wear of the ball. The second operational regime is possible only in the presence of a constant gyroscopic sliding of the balls. P. v. T.

A67-34000
DEFORMATION SUBSTRUCTURE AND SUSCEPTIBILITY TO INTERGRANULAR STRESS CORROSION CRACKING IN AN ALUMINUM ALLOY.
H. A. Holl (Department of Supply, Australian Defence Scientific Service, Aeronautical Research Laboratories, Melbourne, Australia).
Corrosion, vol. 23, June 1967, p. 173-180. 18 refs.

Dislocation arrangements in a deformed aluminum zinc-magnesium-copper alloy aged to various states of susceptibility to stress corrosion cracking have been examined by transmission electron microscopy. Material in a highly susceptible condition deforms in a characteristic manner; slip is concentrated in well defined bands, and dislocations show a marked tendency to remain on their original slip planes. In material exhibiting a low susceptibility, restricted slip does not occur, and dislocations form uniformly distributed tangles. These results are interpreted in terms of existing models for intergranular stress corrosion cracking. It is concluded that when this alloy is aged to contain G.P. zones or coherent precipitates it will be highly susceptible to stress corrosion cracking, whereas when aged to contain noncoherent precipitates the alloy will be highly resistant. (Author)

A67-34121
ACHIEVEMENTS AND EXPERIMENTS IN THE FIELD OF OPEN-CYCLE MHD CONVERTERS [REALISATIONS ET EXPERIMENTATIONS DANS LE DOMAINE DES CONVERTISSEURS MHD A CYCLE OUVERT].
J. Pericart (Electricité de France, Direction des Etudes et Recherches, Département de Magnétohydrodynamique, Paris, France) and J. de Simone (Compagnie Générale d'Electricité, Centre de Recherches, Laboratoire de Dynamique des Fluides, Marcoussis, Seine-et-Oise, France).
Entropie, May-June 1967, p. 29-38. In French.

Discussion of one of the most difficult problems arising in MHD conversion of heat into electricity - the behavior of the nozzle during long-lasting experiments. Research and experiments conducted by Electricité de France and the Compagnie Générale d'Electricité in order to perfect conducting materials and electrical insulators capable of resisting corrosion under the conditions of MHD conversions are discussed. M.F.

A67-34275 #
PARTIAL CONE CRACK FORMATION IN A BRITTLE MATERIAL LOADED WITH A SLIDING SPHERICAL INDENTER.
B. R. Lawn (Bristol, University, H. H. Wills Physics Laboratory, Bristol, England).
Royal Society (London), Proceedings, Series A, vol. 299, July 11, 1967, p. 307-316. 14 refs.

Analysis of the partial cone crack formation in a brittle material loaded with a spherical indenter sliding across the specimen surface, assuming a uniform coefficient of friction over the contact area. Sliding is found to have a large influence on the quasi-static stress field in the loaded specimen, and this in turn affects the ultimate geometry of the cracks. The precise shape of the partially developed cones thus formed is a function only of the Poisson ratio of the specimen material and the coefficient of friction. Criteria determining when surface fracture will occur, expressed as relationships between the critical normal load P_c acting on the specimen and the indenter radius, are calculated. The effect of sliding on the value of P_c becomes large with larger values of the coefficient of friction. T.M.

A67-34368
THE CORRODING IRON SURFACE. II.
A. C. Zettlemoyer (Lehigh University, Center for Surface and Coatings Research, Bethlehem, Pa.) and E. McCafferty.
Journal of Physical Chemistry, vol. 71, July 1967, p. 2452-2456. 15 refs.

Expressions are derived to evaluate hydrogen coverage at a metal surface during dissolution when either the combination mechanism or the electrochemical mechanism of hydrogen evolution is exclusively operative. From cathodic polarization results for the corrosion of iron in the 1 N halogen acids at 25°, in each case the hydrogen coverage appears to be close to unity at the corrosion potential. This evidence supports the concept that nearly the entire iron surface functions as a cathode during corrosion and that only a small part of the surface undergoes dissolution at any given time. (Author)

A67-34455
MICROSTRUCTURE OF "MOLECULAR" CERMETS.
P. P. Budnikov and N. V. Shishkov (Moskovskii Gosudarstvennyi Universitet, Khimiko-Tekhnologicheskii Institut, Moscow, USSR).
(Poroshkovaia Metallurgiia, vol. 6, Nov. 1966, p. 62-65.)
Soviet Powder Metallurgy and Metal Ceramics, Nov. 1966, p. 893-895. 6 refs. Translation.
[For abstract see issue 05, page 830, Accession no. A67-17034]

A67-34579
RESISTANCE OF TITANIUM-BASE ALLOYS TO ATMOSPHERIC CORROSION.
F. L. Plock (Reactive Metals, Inc., Niles, Ohio) and M. L. Greenlee (Titanium Metals Corporation of America, West Caldwell, N.J.).
American Society for Testing and Materials, Annual Meeting, 70th, Boston, Mass., June 25-30, 1967, Paper 31. 3 p. Abridged.

Determination of the atmospheric corrosion behavior of three alpha titanium alloys (commercially pure, 8Al-2Cb-1Ta, and 5Al-2.5Sn), four alpha-beta alloys (6Al-4V, 8Mn, 2Fe-2Cr-2Mo, and 4Al-3Mo-1V), and one beta-type alloy (2.5Al-16V). Tests following exposure to atmospheric corrosion for seven years showed that corrosion resistance is excellent, that staining is slight, that no appreciable metal loss occurs, and that mechanical properties remain essentially unchanged. B.B.

A67-34581
SPECIAL FRACTOGRAPHIC TECHNIQUES FOR FAILURE ANALYSIS.
B. V. Whiteson, A. Phillips, V. Kerlins, and R. A. Rawe (McDonnell Douglas Corp., Missile and Space Systems Div., Santa Monica, Calif.).
American Society for Testing and Materials, Annual Meeting, 70th, Boston, Mass., June 25-30, 1967, Paper 44. 58 p. 9 refs.
Contract No. AF 33(615)-3014.

In order to assist the investigator of service failures, work was performed using electron fractographic methods to resolve problems that have not been solvable using the more conventional macro- or light microscope techniques. Three independent problems were examined: determination of fracture direction in thin sheet metal components, differentiating between hydrogen embrittlement and stress corrosion in high strength steels, and determination of applied cyclic stress as a function of fatigue striation spacing. Fracture direction in thin sheet metal components can be resolved by the combined technique of replicating around the acute angle shear lip of the fracture face and the sheet metal face, and the use of low magnifications on the electron microscope. The direction of tear dimples with respect to the fracture edge consistently indicated the fracture direction in the plane of fracture propagation. Evidence that stress corrosion and hydrogen embrittlement in high strength steel can be separated is examined. (Author)

A67-34676 *
METALLURGICAL ASPECTS OF RELIABILITY FOR SMALL NITRIDED PARTS.
Alfred J. Babecki (NASA, Goddard Space Flight Center, Greenbelt, Md.).
IN: ANNALS OF RELIABILITY AND MAINTAINABILITY; ANNUAL RELIABILITY AND MAINTAINABILITY CONFERENCE, 6TH, COCOA BEACH, FLA., JULY 17-19, 1967, PROCEEDINGS. VOLUME 6 - ALL SYSTEMS GO? [A67-34648 18-15]
Conference sponsored by the Society of Automotive Engineers, the American Society of Mechanical Engineers, and the American Institute of Aeronautics and Astronautics.
New York, Society of Automotive Engineers, Inc., 1967, p. 392-398.

Discussion of three cases of the application of nitrided components in unmanned-satellite drive systems to remedy sliding wear. The cases involve rachets made of Nitralloy 135M on a spectrometer grating drive, nitrided stainless steel gears in a small motor gear train, and a pinion gear on an IR scanner (made of Nitralloy 135M and nitrided to increase its surface hardness). The nitriding technique and the damages sustained by the nitrided components are described. Recommendations are given for use of nitrided components. V.Z.

A67-34789
LUBRICATION WITH ELECTRODEPOSITED FILMS OF SILVER-RHENIUM AND GOLD-MOLYBDENUM.
H. R. Thornton and Z. R. Wolanski (General Dynamics Corp., Fort Worth, Tex.).
(American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Paper.)
Lubrication Engineering, vol. 23, July 1967, p. 271-277; Discussion, G. H. Kitchen (Bell Telephone Laboratories, Inc., Murray Hill, N. J.), p. 277; Authors' Closure, p. 277. 6 refs.

The lubrication mechanisms involved in a class of electrodeposited solid film systems are defined. The Ag-Re and Au-Mo solid film systems demonstrate an open structure when deposited on T-1 steel. This open or porous structure is related to the deposition alloy, deposition processing, and substrate material. The alloying element and temperature also affect the lubrication. The Ag-Re and Au-Mo systems are discussed as to composition, structure, and substrate, and their resultant effect on the boundary layer condition. The effects of environment, such as temperature, on lubrication characteristics are also discussed. (Author)

A67-34790
DEVELOPMENT OF POLYIMIDE BONDED SOLID LUBRICANTS.
M. Campbell and V. Hopkins (Midwest Research Institute, Kansas City, Mo.).
(American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Preprint 67AM 7A-1.)
Lubrication Engineering, vol. 23, July 1967, p. 288-294. 10 refs.
[For abstract see issue 14, page 2326, Accession no. A67-28789]

A67-34888 #
DIAGNOSTIC METHODS OF ROTATING-BEARING DAMAGE [METODY DIAGNOSTIKI POVREZHDENIIA PODSHIPNIKOV KACHENIIA].
A. I. Eroshkin, V. P. Maksimov, and E. A. Samylin.
IN: STRENGTH AND DYNAMICS OF AIRCRAFT ENGINES [PROCHNOST' I DINAMIKA AVIATSIONNYKH DVIGATELEI].
Edited by I. A. Birger, V. M. Darevskii, M. V. Nikulin, S. V. Serensen, and B. F. Shorr.
Moscow, Izdatel'stvo Mashinostroenie, 1966, p. 214-230. In Russian.

Results of experimental study of various methods for diagnosing defects in rotating bearings. The types of bearings, oils, and equipment used in the tests are described. The efficiency of a method of evaluating bearing damage on the basis of shavings found in the oil is discussed. The techniques used in this method include oil-filter inspection, chemical or spectrographic analysis of the oil, magnetic tests, and electronic equipment for detecting the presence of metal in the oil. Another method of damage evaluation used in the tests consisted of observations of variations in rotor motion. The method of measuring variations in the electrical resistance between the bearing and its point of contact is examined. Measurement of acoustical vibrations in bearing housings is also considered. T.M.

A67-34921
SOME PROPERTIES OF CARBIDE AND BORIDE DIFFUSION COATINGS ON REFRACTORY METALS.
A. P. Epik, G. A. Bovkun, I. V. Golubchik, and L. P. Sinitsina.
IN: DIFFUSION CLADDING OF METALS.
Edited by G. V. Samsonov.
(Translation of Diffuzionnye Pokrytiia na Metallakh, Kiev, Izdatel'stvo Naukova Dumka, 1965.)
New York, Consultants Bureau, Division of Plenum Publishing Corp., 1967, p. 81-89. 32 refs.

Study of the resistance to wear, scaling, and chemicals of carbide and boride diffusion coatings on titanium, zirconium, molybdenum, and tungsten. The oxidation of carbided and borided specimens of titanium and zirconium is found to become noticeable only at 700°C or above, the pure metals in every case possessing a much lower resistance to scaling than the carbide and, especially, the borided metals. The increase in weight of the specimens of carbided titanium at 800°C with a holding time of 12 hr is 3.5 times less than the increase in weight of specimens of the pure metal. B.B.

A67-34993 #
LUBRICATING GREASES FOR AERONAUTICAL/AEROSPACE APPLICATIONS.
L. D. New (National Research Council of Canada, Div. of Mechanical Engineering, Fuels and Lubricants Laboratory, Ottawa, Canada).
Canada, National Research Council, Division of Mechanical Engineering and National Aeronautical Establishment, Quarterly Bulletin, no. 1, 1967, p. 73-79. 11 refs.

Study of lubricant requirements for aircraft (apart from engine lubrication) for such items as ball and rollers bearings, gears, splines, actuators, control systems and instruments - which all must be lubricated and function reliably and consistently over a wide range of temperature, speed and load conditions. Lubricants for use under high-temperature, low-temperature, and radiation conditions are indicated, and the limits of lubrication capability are noted. P. v. T.

A67-35822
TECHNOLOGICAL PROBLEMS AND COMPLEX TESTS OF BONDED METAL JOINTS [TECHNOLOGICKÉ PROBLÉMY A NÁROČNĚJŠÍ ZKOUŠKY LEPENÝCH SPOJŮ KOVŮ].
Jindřich Peterka.
Zpravodaj VZLÚ, no. 1, 1967, p. 33-41. In Czech.

Discussion of the importance of surface treatment of metal for ensuring the strength of bonded joints. The main cause of aluminum-alloy corrosion during pickling is attributed to a high concentration of chloride. Test results indicate the possibility of pickling a 1.5-m^2 surface in one liter of pickling solution. It is demonstrated that the surface treatment prior to bonding may be efficiently evaluated only after exposure of the bonded joints to climatic effects. Several adhesives are described which provide satisfactory bond strength when applied at high temperatures and protect the bonding surfaces from polymerization. The advantages of bonded joints in spot welding and riveting are demonstrated by test results on wing skin sections. T.M.

A67-35837
THE LUBRICATION OF STEEL BY ELECTROPLATED GOLD.
Riitsu Takagi (Dayton, University, Research Institute, Dayton, Ohio) and Tung Liu (USAF, Systems Command, Research and Technology Div., Materials Laboratory, Wright-Patterson AFB, Ohio).
(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, ASLE Paper.)
ASLE Transactions, vol. 10, Apr. 1967, p. 115-122; Discussion, Talivaldis Spalvins (NASA, Lewis Research Center, Cleveland, Ohio), H. E. Evans, C. E. Vest (NASA, Goddard Space Flight Center, Greenbelt, Md.), and A. R. Spencer (Bendix Corp., Research Laboratories Div., Southfield, Mich.), p. 122, 123; Authors' Closure, p. 123. 12 refs.

Sliding friction between a 1/8-in. spherical steel rider and a gold-plated steel flat was measured for various loads (200 to 2000 g), gold film thicknesses (0.1 to 10 μ) and steel combinations (440C and 52100). The coefficient of friction recorded in each run for 100 traverses was found to be most sensitive to the rider material (0.1 to 0.3 with 440C rider and 0.1 to 0.6 with 52100 rider, as compared to 0.6 to 0.7 for unlubricated steel). With a 52100 rider, as the number of traverses increases, three distinct types of frictional behaviors were found: (1) slowly decreasing, (2) rapidly decreasing, and (3) increasing (sometimes a minimum was first reached). The theoretical coefficient of friction (0.1) was only observed with "Type 2" results. With a chromium-rich 440C rider, friction was always low, presumably due to its low affinity to gold. (Author)

A67-35838 *
FRICTION CHARACTERISTICS IN VACUUM OF SINGLE AND POLYCRYSTALLINE ALUMINUM OXIDE IN CONTACT WITH THEMSELVES AND WITH VARIOUS METALS.
Donald H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio).
(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, ASLE Paper.)
ASLE Transactions, vol. 10, Apr. 1967, p. 134-143; Discussion, E. J. Duwell (3M Co., St. Paul, Minn.), R. P. Steijn (Du Pont de Nemours and Co., Inc., Wilmington, Del.), and N. S. Eiss, Jr. (Virginia Polytechnic Institute, Blacksburg, Va.), p. 143-145; Author's Closure, p. 145. 42 refs.
[For abstract see issue 03, page 428, Accession no. A67-13231]

A67-35839 *
COLD WELDING TENDENCIES AND FRICTIONAL STUDIES OF CLEAN METALS IN ULTRA-HIGH VACUUM.
C. Eugene Moeller and Michael C. Noland (Midwest Research Institute, Kansas City, Mo.).
(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Minneapolis, Minn., Oct. 18-20, 1966, ASLE Paper.)
ASLE Transactions, vol. 10, Apr. 1967, p. 146-156; Discussion, L. G. Kellogg (North American Aviation, Inc., Atomics International Div., Canoga Park, Calif.), p. 156; Authors' Closure, p. 156, 157. 7 refs.
Contract No. NAS 9-3623.

The degree of cold welding in ultra-high vacuum (10^{-9} torr) was determined for 45 metal combinations. Static coefficients of friction were measured after stationary contact under 9.2-lb load for 300 hours at 200°C. Kinetic coefficients were measured at a velocity of 0.4 in./sec immediately after breakaway. Nearly all of the metal combinations tested exhibited maximum kinetic coefficients higher than the corresponding static coefficients. Metal transfer was from rider to ring when the rider was softer, but followed no pattern when

the ring was softer. Very little correlation was found between the friction characteristics of the metals and their physical properties. (Author)

A67-35840
THE HEAT TRANSFER COEFFICIENT AND LUBRICATED CONTACT TEMPERATURE.
J. P. O'Donoghue, S. M. Manton (Joseph Lucas, Ltd., Research Centre, Solihull, Warwick, England), and A. Cameron (London, University, Imperial College of Science and Technology, Dept. of Mechanical Engineering, London, England).
ASLE Transactions, vol. 10, Apr. 1967, p. 175-180; Discussion, E. F. Leach (Caterpillar Tractor Co., Peoria, Ill.), and R. S. Fein (Texaco, Inc., Beacon, N.Y.), p. 180-182; Authors' Closure, p. 182. 13 refs.

Discussion of the surface-temperature conditions in disks and gears. The theory which predicted the behavior of the surface temperature of machine elements subjected to repeated frictional contacts is applied and extended. In considering the critical-temperature hypothesis proposed by Blok as a criterion for failure by scuffing, it is essential that the operating surface temperature be taken into account in addition to the well known "flash temperature." It is shown that the bulk-temperature growth under loaded conditions can be predicted theoretically and that, by observing the behavior of the surface temperature, the heat-transfer coefficient and friction conditions can be calculated. Full details of the thermocouple used by the authors in their tests are given. M.F.

A67-35850
A STUDY OF THE DRY FRICTION CHARACTERISTICS OF SOME CERMETS AT HIGH SLIDING SPEEDS.
M. E. Belitskii and B. I. Kostetskii (Kievskii Institut Grazhdanskogo Vozdushnogo Flota, Kiev, Ukrainian SSR).
(Fiziko-Khimicheskaia Mekhanika Materialov, vol. 2, Jan.-Feb. 1966, p. 67-71.)
Soviet Materials Science, vol. 2, Jan.-Feb. 1966, p. 51-53. Translation.

Study of the qualitative and quantitative dry-friction characteristics of cermet sealing materials in a wide sliding-speed range (10 to 100 m/sec). The results showed that high temperatures attained by the surface layers of specimens tested at high sliding speeds lead to substantial changes in the structure and properties of these materials and that oxide films formed under these conditions prevent the onset of seizing. Graphite and boron nitride used as solid lubricants in the cermet sealing materials S-120 and UMB-4s act as protective antifriction additives. At sliding speeds higher than 70 m/sec, however, at which high temperatures are generated by friction, graphite burns out; as a result, both the friction coefficients and the rate of wear of material S-120 increase. Boron nitride is a more chemically stable solid lubricant; as a result, both the friction coefficient of material UMB-4s over the entire sliding-speed range investigated and its rate of wear at high sliding speeds are lower than those of material S-120. M.F.

A67-35851
PLASTIC DEFORMATION AND TOPOGRAPHY OF RUBBING SURFACES.
B. I. Kostetskii and N. F. Kolesnichenko (Kievskii Institut Grazhdanskogo Vozdushnogo Flota, Kiev, Ukrainian SSR).
(Fiziko-Khimicheskaia Mekhanika Materialov, vol. 2, Jan.-Feb. 1966, p. 98-104.)
Soviet Materials Science, vol. 2, Jan.-Feb. 1966, p. 73-77. 13 refs. Translation.

Analysis of experimental data relating to processes which take place on surfaces and in surface layers during friction, lubrication, and wear. It is concluded that elastoplastic deformation is an essential part of external friction, being fully responsible for the basic characteristics of the surface interaction, for the formation of friction bonds, and for the onset of various secondary processes in the contact zone. An investigation of the specific features of the physical relief formation involved the examination of specimens deformed in uniaxial tension and compression, studies of the surface geometry of specimens in static and dynamic contact with each other, examination of the physical relief formed during friction in vacuum, and systematic studies of the topography of the working surfaces of some machine parts. Some typical results are presented. M.F.

A67-35866 #
THE INFINITELY LONG PARTIAL ARC SELF-ACTING GAS BEARING - A METHOD OF SOLUTION FOR THE FULL RANGE OF THE COMPRESSIBILITY NUMBER.
C. H. T. Pan, H. Cheng (Mechanical Technology, Inc., Latham, N.Y.), R. J. Wernick (New York, State University, Albany, N.Y.), and L. Ting.
(American Society of Mechanical Engineers, Lubrication Symposium, New Orleans, La., June 5-9, 1966, Paper.)
ASME, Transactions, Series F - Journal of Lubrication Technology, vol. 89, July 1967, p. 263-271. 13 refs.
Contract No. Nonr-3730-(00)(FBM).

Description of the modifications which must be made to Galerkin's method in treating the static solution of an infinitely long partial-arc, self-acting gas bearing. A procedure is described for calculating the loads and the center of pressure for this type of bearing. An artifice is used which reduces the number of three-dimensional arrays to one and considerably simplifies the setup of the solution by Galerkin's method. The artifice has the disadvantage of doubling the number of algebraic equations to be solved and thus increasing the computer time required for their solution. The calculation is arranged in such a way as to use the solution for one case as the initial guess for the next, thereby eliminating difficulties in obtaining convergence of the numerical solution of the algebraic equations for the series coefficients. The described procedure may be extended to similar calculations for the finite-length partial-arc bearing. T.M.

A67-35889 *
POLYMERIC APPLICATIONS FOR THE MARINER MARS, 1964 SPACECRAFT.
R. F. Freeman, R. A. Boundy, and R. Harrington (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
Rubber and Plastics Age, July 1966. 4 p.

Discussion of polymeric materials used for selected subsystems of Mariner 4. The television camera shutter functioned as designed, indicating the efficiency of the polymers chosen as lubricants. The adhesive used on the solar panels held without measurable degradation in the severe environment, and the epoxies and fiberglass laminates used in antenna and feed construction were equally successful. Effective electronic insulation and shielding by polymers were proved under environments of vacuum, radiation, and extreme variations of temperature. P.v.T.

A67-36198 #
MAIN PARAMETERS OF THE WEAR OF PLANE SURFACES IN ALTERNATING MOTION - MODELLING AND MEASURING INSTALLATION. I.
Dan Pavelescu (Rumanian Academy of Sciences, Centre of the Mechanics of Solids, Bucharest, Rumania).
Revue Roumaine des Sciences Techniques, Série de Mécanique Appliquée, vol. 12, no. 2, 1967, p. 485-495. 8 refs.

Study of an installation with six friction pairs for the examination of plane surfaces in to-and-fro motion. The mechanical system includes radiometric and electric circuits for measuring the wear rate, friction force, mean temperature at various points, and the electrical resistance of the lubricating film. Under certain conditions, the relation $\Delta T = KQ^{1/2}$ holds true. B.B.

A67-36273 #
ON THE INFLUENCE OF SOME BOUNDARY CONDITIONS ON GAS LUBRICATION.

V. N. Constantinescu, Fl. Dimopte, and Gh. Marin (Academia Română, Institutul de Mecanică Fluidelor, Bucharest, Rumania). (Conference on Mechanics, Bucharest, Rumania, Sept. 1965, Paper.) Revue Roumaine des Sciences Techniques, Série de Mécanique Appliquée, vol. 12, no. 1, 1967, p. 55-83. 5 refs.

The boundary conditions in self-acting gas bearings having orifices or slots in contact with the atmosphere or supplied with pressurized gas are considered. The problem especially applies to complete journal bearings, since in order to improve the stability of motion orifices or slots are currently used. The influence of a slot is studied in an analytical manner for the simple case of two-dimensional motion. The pressure in the slot is in general nearly equal to the ambient pressure or to the supply pressure. At the same time, in the case of journal bearings the presence of a slot can modify the mass of gas contained in the bearing and consequently the pressure distribution. The theoretical results obtained are qualitatively verified by experimental determinations concerning the pressure distribution in a journal bearing having a slot communicating directly with the atmosphere. (Author)

A67-36485

MICROBES IN AIRCRAFT WING TANKS - FUEL ADDITIVES TO INHIBIT MICROBIAL GROWTH.

Mackie A. Allgood (Federal Aviation Administration, Oklahoma City, Okla.).

Materials Protection, vol. 6, Aug. 1967, p. 26-28. 12 refs.

Discussion of the growth of microbiological organisms in jet-aircraft wing fuel tanks, a major source of corrosion in these facilities. Tests which are conducted under strict controls to determine the efficiency of a microbe-inhibiting additive are described. Treated and untreated fuel tanks of the same aircraft are compared. It is determined that no correlation exists between the number of microbes in the fuel and in the tank water bottoms; the lowest fuel counts occurred after the aircraft had been idle overnight. B.B.

A67-36486

STRESS CORROSION TESTING - VARIOUS TECHNIQUES AND ENVIRONMENTS COMPARED.

Thomas R. Croucher (Northrop Corp., Northrop Norair, Metallurgical Engineering Branch, Physical Metallurgical Section, Hawthorne, Calif.).

Materials Protection, vol. 6, Aug. 1967, p. 44-47. 20 refs.

Description of a joint test program on four precipitation hardening semiaustenitic steels to determine a standard stress corrosion test procedure. Bent-beam and C-ring specimen configurations, 20% salt spray, and 3-1/2% salt alternate immersion environments are evaluated. The bent-beam specimens are shown to provide consistent, repeatable, and stress dependent data, while the data obtained using the C-ring specimens are scattered and unreproducible. The 20% salt spray is severe enough to fail specimens in the 1000-hr test cycle, while the alternate immersion test in 3-1/2% sodium chloride proved ineffective in causing reproducible failures. B.B.

A67-36634

THE CORROSION OF LIGHT METALS.

H. P. Godard (Aluminium Laboratories, Ltd., Kingston, Ontario, Canada), W. B. Jepson (United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Berks., England), M. R. Bothwell (Dow Chemical Co., Metal Products Dept., Midland Mich.), and R. L. Kane (Titanium Metals Corporation of America, Application Development Center, West Caldwell, N.J.).

Research sponsored by the Electrochemical Society.

New York, John Wiley and Sons, Inc., 1967. 367 p.

$13.95.

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PREFACE. H. P. Godard (Aluminium Laboratories, Ltd., Kingston, Ontario, Canada), p. vii, viii.

ALUMINUM. Hugh P. Godard (Aluminium Laboratories, Ltd., Kingston, Ontario, Canada), p. 3-218. 383 refs. [See A67-36635 20-17]

BERYLLIUM. W. B. Jepson (United Kingdom Atomic Energy Authority, Harwell, Berks., England), p. 219-256. 93 refs. [See A67-36636 20-17]

MAGNESIUM. M. R. Bothwell (Dow Chemical Co., Midland, Mich.), p. 259-311. 83 refs. [See A67-36637 20-17]

TITANIUM. Robert L. Kane (Titanium Metals Corporation of America, West Caldwell, N.J.), p. 315-344. 50 refs. [See A67-36638 20-17]

AUTHOR INDEX, p. 345-351.

SUBJECT INDEX, p. 353-360.

A67-36635

ALUMINUM.

Hugh P. Godard (Aluminium Laboratories, Ltd., Kingston, Ontario, Canada).

IN: THE CORROSION OF LIGHT METALS.

Research sponsored by the Electrochemical Society.

New York, John Wiley and Sons, Inc., 1967, p. 3-218. 383 refs.

Investigation of the corrosion behavior of aluminum stressing the condition of the surface film of aluminum oxide, which is relatively inert chemically. Since the definition of corrosion includes both environment and metal, the corrosion resistance of aluminum varies with the environment. When aluminum is in contact with a dissimilar metal other than magnesium, zinc, cadmium, or chromium, in the presence of an electrolyte, it is subject to galvanic corrosion. Localized corrosion which occurs on faying metal surfaces on entry of water into the crevice is termed crevice corrosion. Pitting corrosion, intergranular corrosion, and stress corrosion are explained and discussed. Aluminum alloys show a relatively poor resistance to corrosion fatigue. They have an excellent resistance to atmospheric corrosion because of the mild roughening of the surface which is due to shallow pitting. The most corrosion-resistant aluminum welds are obtained with the nonheat-treatable alloys using the most rapid welding method. As aluminum has a high natural corrosion resistance, corrosion in transportation and storage is mostly caused by condensation and surface abrasion. Seven basic methods to protect aluminum from corrosion are listed, and techniques for the proper cleaning of aluminum surfaces are considered. P.v.T.

A67-36636

BERYLLIUM.

W. B. Jepson (United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Berks., England).

IN: THE CORROSION OF LIGHT METALS.

Research sponsored by the Electrochemical Society.

New York, John Wiley and Sons, Inc., 1967, p. 219-256. 93 refs.

Investigation of beryllium corrosion as it affects the increasing use of beryllium in the U.S. aerospace program. Few corrosion problems seem to have been encountered in such applications, although there have been reports of a highly localized form of corrosion attack on precision gyroscope components after storing. One major conclusion is that the oxidative behavior of beryllium is influenced both by impurities in the metal and by the mode of fabrication. Highly pure beryllium has been produced in small quantities by vacuum distillation and by zone refining. The need for a fine-grained structure in beryllium metal has led to the use of powder metallurgical methods for fabrication. Outside the nuclear field, beryllium is used to make a variety of components for use in precision navigation instruments. Beryllium offers advantages over steel and aluminum in respect to thermal conductivity, modulus of elasticity, and density. The problem of microcreep of the beryllium components after assembly has been overcome by using high-oxide beryllium alloyed with a little iron. P.v.T.

A67-36637

MAGNESIUM.

M. R. Bothwell (Dow Chemical Co., Metal Products Dept., Midland, Mich.).

IN: THE CORROSION OF LIGHT METALS.

Research sponsored by the Electrochemical Society.

New York, John Wiley and Sons, Inc., 1967, p. 259-311. 83 refs.

Study of the nature and prevention of corrosion in magnesium. Magnesium alloys are used without surface protection, or with at most a thin chemical finish, in a number of commercial applications. When environments corrosive to magnesium are expected in service, a variety of chemical and anodic treatments, paint systems, and electroplating techniques have been developed to make magnesium parts serviceable. Effective corrosion prevention begins at the design stage. Galvanic, intergranular, and stress types of corrosion - as well as corrosion fatigue, atmospheric corrosion, and corrosion in selected environments - are discussed. P.v.T.

A67-36638
TITANIUM.
Robert L. Kane (Titanium Metals Corporation of America, Application Development Center, West Caldwell, N.J.).
IN: THE CORROSION OF LIGHT METALS.
Research sponsored by the Electrochemical Society.
New York, John Wiley and Sons, Inc., 1967, p. 315-344. 50 refs.

Investigation of the susceptibility of titanium to corrosion. Protection from attack is achieved by means of passive, self-healing films which form on the metal surface. Film formation is dependent on the environment to which the metal is exposed. Under oxidizing, neutral, or naturally occurring conditions, titanium shows immunity to corrosion as films are maintained. In strongly reducing solutions in which protective films cannot form, rapid attack can occur. In slightly reducing or complexing environments, titanium's behavior depends on the presence of metal ion inhibitors, alloying elements, the temperature and other variables. Areas in which titanium is used extensively, because of improved corrosion performance, are those involving sea water, chemical brines, wet chlorine gas, chlorine dioxide, sodium hypochlorite and chlorine bleaching, nitric acid, organic acids in foods, adipic acids, etc. Titanium is also used for electrodes in fuel cells, for cathodic protection systems, for electrolytic refining of metals, for metal plating, for anodizing racks, and as anodes for generating chlorine and perchlorate. P.v.T.

A67-36842 #
DEFORMATION OF POLYMERS UNDER FRICTION LOADS [DEFORMATSIIA POLIMEROV PRI FRIKTSIONNOM NAGRUZHENII].
P. V. Nazarenko, O. V. Zaitzev, I. I. Agulov, and B. I. Kostetskii (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukrainian SSR).
Mekhanika Polimerov, no. 3, 1967, p. 539-543. 7 refs. In Russian.

Investigation of the distribution of elastic and residual strains caused by friction in the surface layers of polymers. The dependence of these strains on normal pressure, slip rate, and duration of friction loading is established, together with the relation the elastic strains and the antifriction characteristics of the material. The effect of normal and tangential forces on the magnitude of the surface strains is also determined. V.P.

A67-37261
LUBRICATION AND LUBRICANTS.
Edited by E. R. Braithwaite (Climax Molybdenum Company of Europe, Ltd., London, England).
Amsterdam, Elsevier Publishing Co.; New York, American Elsevier Publishing Co., Inc., 1967. 581 p.
$30.

CONTENTS:

PREFACE. E. R. Braithwaite (Climax Molybdenum Company of Europe, Ltd., London, England), p. v-vii.

INTRODUCTORY SURVEY OF LUBRICATION AND WEAR. G. W. Rowe (Birmingham, University, Birmingham, England), p. 1-66. 143 refs. [See A67-37262 20-15]

SOLID LUBRICANTS. J. B. Peace (Acheson Industries/Europe/, Ltd., Plymouth, Devon, England), p. 67-118. 88 refs. [See A67-37263 20-15]

SYNTHETIC LUBRICANTS. D. R. Goddard (Imperial Chemical Industries, Ltd., Ayrshire, Scotland), p. 166-196. 5 refs. [See A67-37264 20-15]

LUBRICATING GREASES. J. H. Harris (Shell Technical Sales Services, London, England), p. 197-268. 60 refs. [See A67-37265 20-15]

PLASTIC-BASED BEARINGS. G. C. Pratt (Glacier Metal Co., Ltd., Alperton, Middx., England), p. 377-426. 14 refs. [See A67-37266 20-15]

AUTHOR INDEX, p. 555-561.

SUBJECT INDEX, p. 563-568.

A67-37262
INTRODUCTORY SURVEY OF LUBRICATION AND WEAR.
G. W. Rowe (Birmingham, University, Dept. of Industrial Metallurgy, Birmingham, England).
IN: LUBRICATION AND LUBRICANTS.
Edited by E. R. Braithwaite.
Amsterdam, Elsevier Publishing Co.; New York, American Elsevier Publishing Co., Inc., 1967, p. 1-66. 143 refs.

Consideration of lubrication and wear with reference to boundary lubrication, fluid films, and solid films. Theories of dry and lubricated sliding and rolling are discussed, and details of laboratory equipment are given. The range of wear conditions is outlined, and wear-test apparatus is described, as well as methods of measuring wear and of surface preparation for wear studies. Corrosive wear and fretting, fatigue, and abrasive wear receive attention. F.R.L.

A67-37263
SOLID LUBRICANTS.
J. B. Peace (Acheson Industries /Europe/, Ltd., Plymouth, Devon, England).
IN: LUBRICATION AND LUBRICANTS.
Edited by E. R. Braithwaite.
Amsterdam, Elsevier Publishing Co.; New York, American Elsevier Publishing Co., Inc., 1967, p. 67-118. 88 refs.

Discussion of solid lubricants, defined as solid materials which reduce the mechanical interaction between surfaces that are in relative motion against the action of a load. Solid lubricant powders, resin-bonded dry film lubricants, dry film lubricants with inorganic binders, dispersions of solids in a nonvolatile carrier, wear-reducing solids, and soft metal films are considered. The effect of metal oxide lubricants on the lubricating behavior of graphite and molybdenum disulfide is examined. An account is given of how solid lubricants are applied to surfaces to get optimum results. F.R.L.

A67-37264
SYNTHETIC LUBRICANTS.
D. R. Goddard (Imperial Chemical Industries, Ltd., Nobel Div., Ayrshire, Scotland).
IN: LUBRICATION AND LUBRICANTS.
Edited by E. R. Braithwaite.
Amsterdam, Elsevier Publishing Co.; New York, American Elsevier Publishing Co., Inc., 1967, p. 166-196. 5 refs.

Consideration of the field of synthetic lubricants, commencing with a discussion of the desirable chemical and physical properties of a nonhydrocarbon lubricant. Viscosity/temperature characteristics, compressibility and bulk modulus, oxidative and thermal stability, volatility, foaming, fire resistance, heat-transfer characteristics, radiation resistance, and compatibility affect the suitability of the lubricant for its application. The principal classes of synthetic lubricants are polyglycols, dibasic acidesters, neopentylpolyol esters, fluoroesters, phosphate esters, silicate esters and disiloxanes, silicones, silanes, polyphenyl esters, chlorinated hydrocarbons, and chlorofluorocarbons. F.R.L.

A67-37265
LUBRICATING GREASES.
J. H. Harris (Shell Technical Sales Services, London, England).
IN: LUBRICATION AND LUBRICANTS.
Edited by E. R. Braithwaite.
Amsterdam, Elsevier Publishing Co.; New York, American Elsevier Publishing Co., Inc., 1967, p. 197-268. 60 refs.

Consideration of the physical and chemical nature, composition, nd characteristics of both soap- and nonsoap-base greases, with omments on additives. Experimental data from a number of sources re given; they include manufacturing and quality control data, and ıformation on performance testing rigs. Suggestions are made on ow to choose the right grease for the right job. Comments are ıade on the value of specifications. F.R.L.

67-37266
LASTIC-BASED BEARINGS.
. G. Pratt (Glacier Metal Co., Ltd., Materials Research Dept., lperton, Middx., England).
N: LUBRICATION AND LUBRICANTS.
dited by E. R. Braithwaite.
msterdam, Elsevier Publishing Co.; New York, American Elsevier ublishing Co., Inc., 1967, p. 377-426. 14 refs.

Review of plastic-based bearings, with exposition of the reasons ›r choosing certain resins. Background polymer chemistry is ıtlined. The use of reinforcing and lubricating fillers is discussed, s well as the incorporation of resins into metallic and nonmetallic ıatrices. Various test rigs are described, and future developments re considered. F.R.L.

67-37465
TRESS-CORROSION CHARACTERISTICS OF A Ti-7Al-2Cb-1Ta ALLOY.
. P. Leckie (United States Steel Corp., Applied Research Labora- ›ry, Monroeville, Pa.).
orrosion, vol. 23, July 1967, p. 187-191. 7 refs.

The study reports the stress-corrosion behavior of a Ti-7Al-Cb-1Ta alloy evaluated using the cantilever-beam testing procedure. he evaluation included effects of applied anodic and cathodic poten- als, specimen loading method, and presence of hydroxyl ion as ıhibitor. When a specimen was loaded in air, stress-corrosion racking could be almost eliminated by allowing the protective oxide lm, ruptured by stress, to heal before adding the electrolyte. tressing the specimen and thus rupturing the passive film in a hloride environment, however, resulted in a very pronounced sus- eptibility to stress-corrosion cracking and short times to failure. otentials more active than -1.3 v (vs saturated calomel electrode) fforded cathodic protection to the alloy tested, which appeared to e immune to hydrogen embrittlement. The studies have shown that ıe stress-corrosion cracking of this titanium alloy is caused by the ıpturing of the protective oxide film followed by stress-corrosion racking by an active path mechanism. (Author)

67-37594
MINE-TIN ANTIOXIDANT SYSTEMS FOR ALIPHATIC HYDRO- ARBONS AND RELATED ALKYL-SUBSTITUTED FLUIDS.
oland E. Dolle (USAF, Systems Command, Research and Tech- ology Div., Materials Laboratory, Fluid and Lubricant Materials ranch, Wright-Patterson AFB, Ohio).
& EC - Industrial and Engineering Chemistry, Product Research nd Development, vol. 6, Sept. 1967, p. 177-183. 25 refs.

Laboratory oxidation and oxidation-corrosion investigations ave shown that the oxidation resistance of two synthetic hydro- arbons, a superrefined mineral oil, a tetraalkyl-substituted silane, nd a dialkyl-substituted pyrazine was greatly enhanced when the ase fluids were inhibited with a two-component antioxidant system omposed of a diaromatic secondary amine and an aromatic tin ompound, but not when the amine and tin compounds were used eparately or when the amine was combined with an aromatic ilicon, phosphorus, lead, or germanium compound. As a result f the improvement gained by the amine-tin combinations, for- ıulated aliphatic hydrocarbons and related fluids withstood ex- osure to severe oxidative stress at 400°F with little degradation. ew antioxidant-containing hydrocarbon formulations now have otential use at the 400 to 425°F level as instrument oils, gear oils, uids for greases, and improved MIL-L-7808 type gas turbine oils. (Author)

A67-37827
APPARATUS FOR PROGRAMMED FEEDING OF CORROSIVE MEDIA IN FATIGUE TESTS.
A. V. Karlashov and A. D. Gnatiuk (Kievskii Institut Grazhdanskogo Vozdushnogo Flota, Kiev, Ukrainian SSR).
(Fiziko-Khimicheskaia Mekhanika Materialov, vol. 2, Mar.-Apr. 1966, p. 167-169.)
Soviet Materials Science, vol. 2, Mar.-Apr. 1966, p. 120, 121. Translation.

Description of an automatic apparatus with the aid of which test specimens can be flooded or sprayed with liquid corrosive media according to a predetermined program, in order to ascertain the action of various corrosive media, such as atmospheric moisture, sea water, pressurized cabin condensate, chemical particles, etc., to which aircraft parts are exposed. An important advantage of this improved programing device is that the duration of the programed cycle can be varied within wide limits (3 to 90 min); this is effected with the aid of the programing disk of the outermost contactor. In the industrial model the programed cycle is constant and equal to the maximum programed time interval. P.v.T.

A67-38134
CONFERENCE ON LUBRICATION AND WEAR: FUNDAMENTALS AND APPLICATION TO DESIGN, LONDON, ENGLAND, SEPTEMBER 25-29, 1967, PAPERS. SESSION 2 - FLUID FILM LUBRICATION.
London, Institution of Mechanical Engineers, 1967. 94 p. Price of six volumes, $28.50.

CONTENTS:

RECENT DEVELOPMENTS IN FLUID FILM LUBRICATION THEORY. T. Lloyd and H. McCallion (Nottingham University, Nottingham, England), p. 3-17. 96 refs. [See A67-38135 21-15]

ROTOR STABILITY. B. Sternlicht (Mechanical Technology, Inc., Latham, N.Y.), p. 49-66. 75 refs. [See A67-38136 21-15]

GAS BEARINGS - JOURNAL AND THRUST. W. A. Gross (Ampex Corp., Redwood City, Calif.), p. 83-95. 56 refs. [See A67-38137 21-15]

A67-38135
RECENT DEVELOPMENTS IN FLUID FILM LUBRICATION THEORY.
T. Lloyd and H. McCallion (Nottingham University, Dept. of Mechanical Engineering, Nottingham, England).
IN: CONFERENCE ON LUBRICATION AND WEAR: FUNDAMENTALS AND APPLICATION TO DESIGN, LONDON, ENGLAND, SEPTEMBER 25-29, 1967, PAPERS. SESSION 2 - FLUID FILM LUBRICATION. [A67-38134 21-15]
London, Institution of Mechanical Engineers, 1967, p. 3-17. 96 refs.

Examination of the role of high-speed electronic computers in extending progress in fluid film lubrication over the past ten years. Static and dynamic oil film parameters have been computed for a wide range of finite geometries, for hydrostatic and hydrodynamic bearings lubricated by compressible and incompressible lubricants. Much use has been made of iterative finite difference schemes, which are particularly well suited to digital computers, and these methods are now more fully understood. Other methods of solution include direct inversion of finite difference matrices and solution by expression of the pressure by some infinite series, a finite number of terms of which give adequate representation. Besides the increase in design data available, there has been substantial progress through a re-examination of the effects of modifying some of the assumptions inherent in most of the available solutions of the Reynolds equation. These include the assumption of constant lubricant viscosity, of rigid surfaces and of laminar flow. The interaction of the lubricant film with elastic boundaries has been shown to be of prime importance in highly loaded contacts such as gears, and this has led to the development of the special topic of elasto-hydrodynamic lubrication theory. The applicability of gas bearings in such growing industries as computers, space vehicles, and nuclear reactors has resulted in great activity and progress in this field. (Author)

A67-38138
CONFERENCE ON LUBRICATION AND WEAR: FUNDAMENTALS AND APPLICATION TO DESIGN, LONDON, ENGLAND, SEPTEMBER 25-29, 1967, PAPERS. SESSION 4 - LUBRICATION AND MATERIALS.
London, Institution of Mechanical Engineers, 1967. 119 p.
Price of six volumes, $28.50.

CONTENTS:
SOLID FRICTION AND BOUNDARY LUBRICATION. D. Tabor (Cambridge University, Cambridge, England), p. 3-20. 98 refs. [See A67-38139 21-15]

A67-38139
SOLID FRICTION AND BOUNDARY LUBRICATION.
D. Tabor (Cambridge University, Cavendish Laboratory, Surface Physics Sub-Dept., Cambridge, England).
IN: CONFERENCE ON LUBRICATION AND WEAR: FUNDAMENTALS AND APPLICATION TO DESIGN, LONDON, ENGLAND, SEPTEMBER 25-29, 1967, PAPERS. SESSION 4 - LUBRICATION AND MATERIALS. [A67-38138 21-15]
London, Institution of Mechanical Engineers, 1967, p. 3-20.
98 refs.

Discussion of lubrication and wear problems relating to the surfaces of solid materials. The influence of the area of contact and of adhesion of surfaces is considered, and the deformation term and intermittent motion of sliding mechanisms are investigated. Friction in a very high vacuum, of nonmetals, lamellar solids, rubber, and rigid polymers is studied. The effects of surface speed, temperature, and environment on friction are evaluated. The influence of boundary lubrication, physical adsorption, chemisorption or chemical reaction, and the thickness and mechanical properties of the surface film is described. B.B.

A67-38140
CONFERENCE ON LUBRICATION AND WEAR: FUNDAMENTALS AND APPLICATION TO DESIGN, LONDON, ENGLAND, SEPTEMBER 25-29, 1967, PAPERS. SESSION 5 - SPECIFIC ENVIRONMENTS.
London, Institution of Mechanical Engineers, 1967. 91 p.
Price of six volumes, $28.50.

CONTENTS:
COLD ENVIRONMENTS. D. H. Tantam (British Oxygen Co., Ltd., London, England), p. 29-40. 11 refs. [See A67-38141 21-15]
LUBRICATION AND WEAR FUNDAMENTALS FOR HIGH-VACUUM APPLICATIONS. R. L. Johnson and D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio), p. 41-52. 31 refs. [See A67-38142 21-15]
EFFECT OF THE SPACE ENVIRONMENT ON LUBRICANTS AND ROLLING ELEMENT BEARINGS. W. J. Anderson and D. C. Glenn (NASA, Lewis Research Center, Cleveland, Ohio), p. 68-81. 25 refs. [See A67-38143 21-15]

A67-38142 *
LUBRICATION AND WEAR FUNDAMENTALS FOR HIGH-VACUUM APPLICATIONS.
R. L. Johnson (NASA, Lewis Research Center, Lubrication Branch, Cleveland, Ohio) and D. H. Buckley (NASA, Lewis Research Center, Lubrication Branch, Space Environment Lubrication Section, Cleveland, Ohio).
IN: CONFERENCE ON LUBRICATION AND WEAR: FUNDAMENTALS AND APPLICATION TO DESIGN, LONDON, ENGLAND, SEPTEMBER 25-29, 1967, PAPERS. SESSION 5 - SPECIFIC ENVIRONMENTS. [A67-38140 21-15]
London, Institution of Mechanical Engineers, 1967, p. 41-52.
31 refs.

The problems of lubrication and wear in vacuum are mostly caused by the low pressure and the lack of oxygen. Important considerations are: (1) inability to maintain oxide films, (2) evaporation of lubricants, and (3) poor heat transfer. The usefulness of the adhesion concept of friction is demonstrated by correlation of cleavage and adhesion studies with sliding friction. Behavior of solids in these areas of study is significantly influenced by crystal structure and atomic bonding forces. Better definition of surface, lubricating films, and slider material on the basis of atomic arrangement in crystals and molecules is required for continued progress. Metals and alloys with hexagonal crystal structure and a c/a stacking ratio approaching ideal (1.633) have useful friction and wear properties. Crystal structures of inorganic lubricants are also important. Adhesion between surfaces in sliding contact may result in junctions formed from (1) diffusion bonding - i.e., solid solubility, (2) chemical bonding, and (3) mechanical bonding. Material transfer occurs during sliding with most material combinations by one or more of these adhesion processes. Properties such as the proper hexagonal structure or contamination films that cause subsequent shearing to occur in the plane and region of the original interface will minimize adhesive wear. Friction responds to factors such as crystal structure that influence the shear strength of metal junctions. Methods for maintaining useful surface contamination and obtaining proper crystalline structure are the most promising areas for study in achieving efficient operation of sliding surfaces in vacuum. The problems as well as materials for their solutions need to be defined on the basis of atomic structure. (Author)

A67-38143 *
EFFECT OF THE SPACE ENVIRONMENT ON LUBRICANTS AND ROLLING ELEMENT BEARINGS.
W. J. Anderson (NASA, Lewis Research Center, Bearings Branch, Cleveland, Ohio) and D. C. Glenn (NASA, Lewis Research Center, Cleveland, Ohio).
IN: CONFERENCE ON LUBRICATION AND WEAR: FUNDAMENTALS AND APPLICATION TO DESIGN, LONDON, ENGLAND, SEPTEMBER 25-29, 1967, PAPERS. SESSION 5 - SPECIFIC ENVIRONMENTS. [A67-38140 21-15]
London, Institution of Mechanical Engineers, 1967, p. 68-81.
25 refs.

The effects of spatial environmental factors such as the very low ambient pressure and the absence of oxygen on lubrication are discussed. The low pressure causes liquids, and even solids, to boil away, so that their vapor pressure and evaporation rates become important. Evaporation experiments with metals, liquids, greases, and solid lubricants are discussed. Silicone oils and silicone-based greases appear to have the lowest evaporative loss among the fluids investigated. Bearing experiments indicate that liquids and greases, when properly shielded, can provide longer bearing lives than bonded solid lubricants or metal platings. Silicone fluids yield the best bearing life, confirming the results of evaporation tests. Life results with bonded solid films are generally poor. Results are considerably better when the solid lubricant is used as a constituent in a solid-composite material. Bearing reliability in space applications may be a problem because considerable life scatter is observed where a particular lubricant or lubrication technique is evaluated in multiple tests. Life ratios of 10 were common. (Author)

A67-38144
CONFERENCE ON LUBRICATION AND WEAR: FUNDAMENTALS AND APPLICATION TO DESIGN, LONDON, ENGLAND, SEPTEMBER 25-29, 1967, PAPERS. SESSION 6 - SYNTHESIS.
London, Institution of Mechanical Engineers, 1967. 11 p.
Price of six volumes, $28.50.

CONTENTS:
SELECTION OF BEARINGS. M. J. Neale, p. 3-12. 7 refs. [See A67-38145 21-15]

A67-38178
PROCESSING PRECIPITATION HARDENING GRADES.
John A. Burger (General Motors Corp., Indianapolis, Ind.) and Dean K. Hanink (General Motors Corp., Allison Div., Materials Laboratories, Indianapolis, Ind.).
Metal Progress, vol. 92, Aug. 1967, p. 143-145.

Review of the heat-treatment practices used for various grades f precipitation-hardening steels. The importance of these steels or missile and aerospace applications, due to their optimal orrosion resistance, is emphasized. The main properties of these rades are given, and the appropriate heat-treatment practices - .g., homogenization, full annealing, solution treatment, precipita- on hardening, and transformation cooling - are briefly described. . "fact sheet" with a summarization of various heat treatments for recipitation hardening alloys and a graph showing how age hardening ffects 17-4PH steel is given. Suggestions for specific heat-treatment quipment and the utilization of protective atmospheres - e.g., acuum, H, He, argon, endothermic and exothermic gases - are iven. A.B.

67-38832 #
ETERMINATION OF THE OPTIMAL PARAMETERS OF AN LASTICALLY DAMPING TURBINE-ROTOR BEARING [K OPRE- ELENIIU OPTIMAL'NYKH PARAMETROV UPRUGO-DEMPFERNOI PORY ROTORA TURBOMASHINY].
. A. Kriukov.
N: STUDY OF VIBRATIONS AND THE STRENGTH OF AIRCRAFT- NGINE COMPONENTS [ISSLEDOVANIE VIBRATSII I PROCHNOSTI ETALEI AVIADVIGATELEI].
dited by G. S. Skubachevskii.
loscow, Izdatel'stvo Mashinostroenie (Moskovskii Aviatsionnyi nstitut, Trudy, No. 172), 1967, p. 22-49. 8 refs. In Russian.

Analysis of the functional parameters of a damping turbine-otor bearing in order to determine the critical velocities of the haft. The parameters considered include deformation of the shaft n the direction of friction, coefficients of dynamic amplification, mplitudes of deflection, angles of deformation displacement in elation to the driving force, unbalanced forces, and stresses in ne shaft. The operating conditions of an elastically damping bearing re examined in relation to these parameters, and various methods re described for determining the optimal bearing parameters in he case of elevated lubricant temperatures. Conditions are studied uring which shaft deformation in the direction of friction may be eglected. T. M.

67-38834 #
'ORCED VIBRATIONS OF A FREE SHAFT WITH FRICTION VYNUZHDENNYE KOLEBANIIA SVOBODNOGO VALA S TRENIEM].
. A. Artemov.
N: STUDY OF VIBRATIONS AND THE STRENGTH OF AIRCRAFT- NGINE COMPONENTS [ISSLEDOVANIE VIBRATSII I PROCHNOSTI ETALEI AVIADVIGATELEI].
dited by G. S. Skubachevskii.
loscow, Izdatel'stvo Mashinostroenie (Moskovskii Aviatsionnyi nstitut, Trudy, No. 172), 1967, p. 56-72. In Russian.

Determination of the amplitudes of the forced flexural vibrations f a freely rotating shaft having an arbitrary profile under the action f an arbitrary load with n dampers. The shaft is considered to be inearly deformed, and the dampers are hydraulic, with friction roportional to the rate of vibration. The distributed bending moments f the shaft's inertial forces are not considered, due to their small alues. An integral method is described for determining the vibra- ions of the free shaft, taking into account viscous friction. For- nulas are derived for the amplitude-frequency characteristics of a otating shaft, accounting for mass distribution and for the influence f the gyroscopic moments of disks. A numerical example is given or a system having two damping arrangements, but the proposed nethod is also applicable to systems having a larger number of amping arrangements. T. M.

67-38837 #
'HE HYDROSTATIC BEARING AS A SOURCE OF VIBRATIONS O GIDROSTATICHESKOM PODSHIPNIKE KAK ISTOCHNIKE KOLE- BANII].
G. A. Ivanov.
IN: STUDY OF VIBRATIONS AND THE STRENGTH OF AIRCRAFT-ENGINE COMPONENTS [ISSLEDOVANIE VIBRATSII I PROCHNOSTI DETALEI AVIADVIGATELEI].
Edited by G. S. Skubachevskii.
Moscow, Izdatel'stvo Mashinostroenie (Moskovskii Aviatsionnyi Institut, Trudy, No. 172), 1967, p. 89-93. 5 refs. In Russian.

Analysis of the load-carrying capacity of a hydrostatic bearing having communicating chambers and operating with a laminar flow of incompressible fluid. Experimental results are described for shaft vibrations with three- and five-chamber bearings. It is shown that a change from a three-chamber to a five-chamber bearing eliminates undesirable vibrations associated with an unequal supporting capability of the lubricant layer. T. M.

A67-39008
CORROSION-FATIGUE STRENGTH OF ALUMINUM-CLAD D16AT ALLOY SHEET UNDER ASYMMETRICAL LOADS.
A. V. Karlashov and A. D. Gnatiuk (Kievskii Institut Grazhdanskogo Vozdushnogo Flota, Kiev, Ukrainian SSR).
(Fiziko-Khimicheskaia Mekhanika Materialov, vol. 2, May-June 1966, p. 279-284.)
Soviet Materials Science, vol. 2, May-June 1966, p. 202-205. 5 refs. Translation.

Investigation of the effect of the mean stress level (σ_m) on the corrosion-fatigue strength of aluminum-clad alloy sheet D16AT. The results obtained show that the mean alternating stress level σ_m has a substantial effect on the fatigue and corrosion-fatigue strength of alloy D16AT. As the level of σ_m increases, the effect of the action of a 3% NaCl solution on the endurance of the D16AT alloy becomes more pronounced, but only in the low-endurance range. Increasing σ_m in the high-endurance range reduces the harmful effect of the corrosive medium. Tests both in air and in a corrosive medium revealed that in either case there is a range of σ_m in which an increase in σ_m causes no reduction in the endurance of the alloy investigated. M.M.

A67-39009
EFFECT OF SOME FACTORS OF PROGRAMMED LOADING ON THE ENDURANCE OF AN ALUMINUM ALLOY IN A CORROSIVE MEDIUM.
A. V. Karlashov and A. D. Gnatiuk (Kievskii Institut Grazhdanskogo Vozdushnogo Flota, Kiev, Ukrainian SSR).
(Fiziko-Khimicheskaia Mekhanika Materialov, vol. 2, May-June 1966, p. 285-292.)
Soviet Materials Science, vol. 2, May-June 1966, p. 206-209. 7 refs. Translation.

Experimental investigation of the effect of some variable-load factors on the durability of the D16T alloy continuously exposed to the action of a corrosive medium. It was found that the initial stress in fatigue tests under a varying stress application may have a considerable effect on the endurance of the D16T alloy, particularly in air. The application of high initial stresses leads to an increase in endurance, the extent of the increase depending on the character of the load sequence employed. The accumulation of fatigue damage during tests under a varying stress application is more intense in corrosive media than in air. When the ratio of the number of cycles at stresses below the corrosion-fatigue limit σ_{-1} to that at stresses above this limit is 1:1, the durability of the D16T alloy tested in a 3% solution of NaCl under a varying stress application is not affected by stresses lower than $0.5\ \sigma_{-1}$. M.M.

A67-39010
PHYSICO-MECHANICAL AND CORROSION PROPERTIES OF HEAT-RESISTANT STAINLESS STEEL EP-479.
V. V. Smirnov, V. I. Pokhmurskii, and A. V. Boltarovich (Akademiia Nauk Ukrainskoi SSR, Fiziko-Mekhanicheskii Institut, Lvov, Ukrainian SSR).
(Fiziko-Khimicheskaia Mekhanika Materialov, vol. 2, May-June 1966, p. 304-307.)
Soviet Materials Science, vol. 2, May-June 1966, p. 218-220. Translation.

Evaluation of the physical, mechanical, and electrochemical properties of stainless steels Kh17N2 and EP-479. The experimental results obtained showed that EP-479, while matching the strength and fatigue properties of steel Kh17N2 at room temperature, has better corrosion resistance and higher strength at elevated temperatures. The optimum heat treatment of this steel consists of oil quenching from 1040°C and tempering at 570 or 650 to 680°C. The results of long-time tensile tests, creep tests, and fatigue tests, carried out at 400 to 500°C, showed that both the creep limit and long-time tensile strength of the EP-479 steel are higher than those of the Kh17N2 steel. M.M.

A67-39219 #
INFLUENCE OF SURFACE-ACTIVE LUBRICANTS ON THE INTERNAL STRESSES IN THE CASE OF SIGN-VARIABLE SLIPPAGE [O VLIIANII POVERKHNOSTNOAKTIVNOI SMAZKI NA VNUTRENNIE NAPRIAZHENIIA PRI ZNAKOPEREMENNOM SKOL'ZHENII].
V. D. Evdokimov (Odesskii Elektrotekhnicheskii Institut Sviazi, Odessa, Ukrainian SSR).
Akademiia Nauk SSSR, Doklady, vol. 175, Aug. 1, 1967, p. 810-812. 15 refs. In Russian.

Experimental investigation of the effect of surface-active additions (octyl alcohol and oleic acid) to inactive nonpolar liquid petrolatum on the wear resistance of steels in the case of bidirectional sliding friction involving shearing stresses. It is found that the physical absorption of alcohol changes the conditions of friction but does not change the distribution of the internal stresses, as observed when using lubricants without surface-active additions. On the other hand, active chemisorption produced by oleic acid results in a substantial change in the internal-stress curves, eliminates the effect of bidirectional slippage and increases the wear resistance appreciably. V.P.

A67-39232 #
STATIC REACTION OF A RADIAL GASDYNAMIC BEARING TO THE ANGULAR DISPLACEMENT OF THE JOURNAL AXIS [STATICHESKAIA REAKTSIIA RADIAL'NOGO GAZODINAMICHESKOGO PODSHIPNIKA NA UGLOVOE SMESHCHENIE OSI SHIPA].
Iu. R. Ivanov (Leningradskii Institut Aviatsionnogo Priborostroeniia, Leningrad, USSR).
Priborostroenie, vol. 10, no. 7, 1967, p. 112-115. In Russian.

Discussion of the pressure function of a radial gasdynamic bearing of finite length having an angularly displaced journal axis. The function is determined by splicing asymptotic solutions for low- and high-pressure levels. Expressions for the restoring moment are obtained for shafts mounted on two radial bearings or on a single central bearing. V.Z.

A67-39284
EVALUATION OF THE RELIABILITY OF STRUCTURAL COMPONENTS SUBJECTED TO OSCILLATIONS [BEURTEILUNG DER ZUVERLÄSSIGKEIT SCHWINGBEANSPRUCHTER BAUTEILE].
E. Haibach (Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung, Laboratorium für Betriebsfestigkeit, Darmstadt, West Germany).
(Nachrichtentechnische Gesellschaft, Tagung über technische Zuverlässigkeit, Nuremberg, West Germany, Apr. 1967, Paper.)
Luftfahrttechnik Raumfahrttechnik, vol. 13, Aug. 1967, p. 188-193. 9 refs. In German.

Determination of the life span and reliability of structural components subjected to oscillations, on the basis of the dispersion distributions of the tolerable oscillation stress and the actually occurring operational stress. An attempt is made to develop a consistent theory for carrying out such evaluations. The difficulties arising in a practical application are outlined, and a solution is indicated by means of a simplified calculation of the probability of a breakdown. P.v.T.

A67-39315
FRICTION AND WEAR IN MACHINERY. VOLUME 18.
Edited by M. M. Khrushchov.
(Translation of Novoe o Smazke v Mashinakh. Volume 18, 1964.)
New York, American Society of Mechanical Engineers, 1967.
232 p. 236 refs.
Members, $6.00; nonmembers, $7.50.

CONTENTS:
PREFACE TO THE ENGLISH TRANSLATION. M. D. Hersey. 1 p.
STUDY OF THE STABILITY OF THE EQUILIBRIUM OF A RIGID ROTOR IN AERODYNAMIC BEARINGS. G. A. Pospelov, p. 42-88. 21 refs. [See A67-39316 22-15]
SOME PROBLEMS OF ELASTORHEOLOGY HAVING AN APPLICATION IN THE THEORY OF FRICTION. M. V. Korovchinskii, p. 89-212. 51 refs. [See A67-39317 22-15]

A67-39316
STUDY OF THE STABILITY OF THE EQUILIBRIUM OF A RIGID ROTOR IN AERODYNAMIC BEARINGS.
G. A. Pospelov.
IN: FRICTION AND WEAR IN MACHINERY. VOLUME 18.
Edited by M. M. Khrushchov.
(Translation of Novoe o Smazke v Mashinakh. Volume 18, 1964.)
New York, American Society of Mechanical Engineers, 1967, p. 42-88. 21 refs.

Theoretical and experimental study of the stability of the equilibrium position of a rigid, balanced, two-bearing rotor in aerodynamic bearings without blowing. Stodola's method is used, allowing for the position forces acting on the rotor neck in a disturbed position. Emphasis is on determination of the lubricant reaction on the journal and on derivation of analytical relationships which give results nearest to those obtained by the numerical method of calculation. A study of journal stability has shown that a region of stable equilibrium extending over the entire range of variation of the relative eccentricity exists in gas-lubricated bearings. B.B.

A67-39317
SOME PROBLEMS OF ELASTORHEOLOGY HAVING AN APPLICATION IN THE THEORY OF FRICTION.
M. V. Korovchinskii.
IN: FRICTION AND WEAR IN MACHINERY. VOLUME 18.
Edited by M. M. Khrushchov.
(Translation of Novoe o Smazke v Mashinakh. Volume 18, 1964.)
New York, American Society of Mechanical Engineers, 1967, p. 89-212. 51 refs.

Determination of the extent of a lubricating film for which the oil flow is approximately plane, and of the influence of lubricant compressibility and heat release in the lubricant film on its load-carrying capacity and on the pressure distribution in it. The values of the characteristic dimensionless parameters for which the lubricant behaves like an incompressible fluid are also derived. All theoretical data are compared with the available experimental results on the relative motion of well lubricated cylinders. B.B.

A67-39395 #
SYNCHRONOUS MOTIONS IN A SYSTEM OF PLANTS WITH BEARING COUPLINGS [SINKHRONNYE DVIZHENIIA V SISTEME OB'EKTOV S NESUSHCHIMI SVIAZAMI].
R. F. Nagaev and K. Sh. Khodzhaev.
Prikladnaia Matematika i Mekhanika, vol. 31, July-Aug. 1967, p. 631-642. In Russian.

Discussion of the general synchronization problem of dynamic systems in terms of a synchronous motion of essentially nonlinear, nearly conservative plants with one degree of freedom, interacting through two kinds of weak coupling. It is assumed that elements of one kind of coupling have no intrinsic degrees of freedom and that oscillations of the other kind of coupling (the bearing system) involve a substantial energy dissipation. Expressions for the motion are derived in the form of Routh equations for the additional kinetic potential of plants due to the small oscillations of the bearing system.

Also derived are periodic solutions for rotational motion of a generalized dynamic system containing a fast rotating phase. The necessary and sufficient conditions for stability are determined for such systems, and the possibility of representing these conditions by averaged energy characteristics of this motion is evaluated. An expression for the integral stability criterion of such systems is given. This expression is also valid in the presence of gyroscopic forces in the bearing system. V.Z.

A67-40060
AN INCUBATION TIME FOR THE INITIATION OF STRESS-CORROSION CRACKING IN PRECRACKED 4340 STEEL.
W. D. Benjamin and E. A. Steigerwald (TRW, Inc., TRW Equipment Laboratories, Cleveland, Ohio).
ASM Transactions Quarterly, vol. 60, Sept. 1967, p. 547, 548. 5 refs.
Contract No. AF 33(615)-3651.

Investigation of the nature of the incubation period of the environmentally induced delayed-failure process in precracked 4340 steel. The specimens were stressed in the environment for a time sufficient to allow some crack growth. The results of aging studies suggest that the incubation period represents the time required for the environment to permeate or dissolve a film which is formed at the crack tip between the precracking and testing operations in the absence of water. The data obtained indicate that the incubation period is caused by film formation which protects the metal from the environment. This film, once destroyed or permeated by the environment, does not reform during the stress-corrosion process and apparently has little influence on the subsequent crack-growth mechanism. M.M.

A67-40218
EFFECT OF ELECTRICAL CURRENTS ON BALL BEARING DAMAGE IN VACUUM AND IN AIR.
S. F. Murray Asle and P. Lewis Asle (Mechanical Technology, Inc., Latham, N.Y.).
(American Society of Lubrication Engineers, Annual Meeting, 22nd, Toronto, Canada, May 1-4, 1967, Preprint 67AM 1C-1.)
Lubrication Engineering, vol. 23, Sept. 1967, p. 363-371.
[For abstract see issue 14, page 2325, Accession no. A67-28783]

A67-40332
HIGH-EFFICIENCY MATERIALS.
A. W. Bethune (Boeing Co., Commercial Airplane Div., Materials Research Unit, Seattle, Wash.) and R. A. Davis (Boeing Co., Commercial Airplane Div., Metals Unit, Seattle, Wash.).
Space/Aeronautics (Research and Development Issue), vol. 48, July 31, 1967, p. 64-68.

Discussion of the elements of high structural efficiency of aircraft materials. It is emphasized that, along with tensile and compressive ultimate and yield strengths, moduli, and ductility, the improvement of fatigue characteristics, fracture toughness, and corrosion resistance is imperative for achieving a higher structural efficiency in terms of cost effectiveness. The structural efficiency of steel, aluminum, and titanium alloys and fiber-reinforced composite materials, including the first "flying" boron-resin composite, is reviewed. The performance of a group of low-solubility reinforcement materials is assessed. V.Z.

A67-40596 #
TEMPERATURE DEPENDENCE OF THE ACTUAL CONTACT AREA AND THE FRICTION FORCES IN HIGHLY ELASTIC MATERIALS [TEMPERATURNAIA ZAVISIMOST' PLOSHCHADI FAKTICHESKOGO KONTAKTA I SILY TRENIIA VYSOKOELASTICHNYKH MATERIALOV].
G. M. Bartenev, V. V. Lavrent'ev, and N. A. Konstantinova (Moskovskii Gosudarstvennyi Pedagogicheskii Institut, Problemnaia Laboratoriia Fiziki Polimerov, Moscow, USSR).
Mekhanika Polimerov, no. 4, 1967, p. 726-729. 11 refs. In Russian.

Optical study of the sliding-friction forces and the actual contact area between butadiene-nitrile rubber samples and smooth solid surfaces, under loads from 4 to 0.4×10^5, 2.5 to 1.8×10^5, and 6×10 n/m^2 at temperatures from 300 to 380°K. The decrease of the elastic modulus with temperature is found to affect the temperature dependence of the actual contact area of these materials under load. The friction constant is found to be an inverse linear function of temperature regardless of the applied load. V.Z.

A67-40899
PERFORMANCE OF EXCEPTIONAL METALS IN CORROSIVE ENVIRONMENTS.
Norman E. Hamner (National Association of Corrosion Engineers, Inc., Houston, Tex.).
Materials Protection, vol. 6, Oct. 1967, p. 31-39. 65 refs.

Study of a wide variety of metals which are noted for their corrosion/temperature-resistance characteristics. Among the metals considered from the point of view of their application in atomic power systems, thermoelectric generators, coatings, and thermionic converters are: barium, beryllium, bismuth, boron, cesium, cobalt, columbium, gallium, germanium, mercury, molybdenum, plutonium, tantalum, titanium, tungsten, uranium, and zirconium. R.B.S.

A67-41062
WEAR OF POLYTETRAFLUOROETHYLENE - FUNDAMENTAL BEHAVIOR.
Kyuichiro Tanaka, Yoshitaka Uchiyama, and Satoru Toyooka (Kanazawa University, Faculty of Technology, Kanazawa City, Japan).
Japan Society of Lubrication Engineers, Journal, vol. 12, no. 1, 1967, p. 31-39. 9 refs. In Japanese.

Study of the wear characteristics of polytetrafluoroethylene (PTFE) over a 500 to 2500-g load range at a sliding speed of 30 cm/sec. Flat ends of cylindrical PTFE rods are rubbed against flat plates of tool steel and glass. Measurements of the friction and height variations of the rods are made continuously on the wear processes under a vacuum of about 10^{-5} torr. The wear rate of PTFE on glass under high loads is found to be more severe in air, although it is nearly the same as in the vacuum under lower loads; generally the wear rate of PTFE on glass seems proportional to the contact pressure in a range of low pressures. B.B.

A67-41063
A STUDY OF BOUNDARY FRICTION BETWEEN METAL SURFACES.
Yoshitsugu Kimura (Tokyo, University, Dept. of Engineering, Tokyo, Japan).
Japan Society of Lubrication Engineers, Journal, vol. 12, no. 3, 1967, p. 123-132. 8 refs. In Japanese.

Theoretical analysis of frictional processes of metal surfaces under boundary-lubrication conditions, emphasizing the initiation of seizure. The mechanism of boundary friction is investigated, the initiation of seizure being regarded as a process of formation and growth of a nucleus created by a thermal disturbance of the lubricating film. Copper vs copper frictional processes using caprylic acid lubricant are calculated; the results are compared with experimental data and show good agreement. B.B.

A67-41342
FULL JOURNAL BEARINGS IN TURBULENT AND LAMINAR REGIMES.
A. Szeri and D. Powers (Universidad Técnica Federico Santa María, Valparaíso. Chile).
Journal of Mechanical Engineering Science, vol. 9, June 1967, p. 167-176. 12 refs.

An equation in lubricant pressure is derived, based on Prandtl's mixing-length theory, under general loading conditions. This nonhomogeneous partial differential equation is amenable to reduction by separation of variables. One of the resulting ordinary equations is integrated directly, while the other is solved by a direct method. The solution is subject to zero pressure boundary conditions; for the long bearing both the pressure and its gradient vanish at the trailing edge. The approximate eigenfunctions are given as truncated sine series, and the eigenvalues are bounded. Design figures are presented for journal bearings under static loading in both laminar and turbulent regimes. (Author)

A67-41409 *
A CASE HISTORY OF TITANIUM STRESS CORROSION IN NITROGEN TETROXIDE.
Robert E. Johnson (NASA, Manned Spacecraft Center, Houston, Tex.), George F. Kappelt (Bell Aerospace Corp., Bell Aerosystems Co., Laboratories and Test Dept., Buffalo, N.Y.), and Larry J. Korb (North American Aviation, Inc., Metallics Group, Downey, Calif.).
American Society for Metals, National Metals Congress, Chicago, Ill., Oct. 31-Nov. 3, 1966, Paper C6-2.2. 19 p. 9 refs.
Members, $1.50; nonmembers, $3.00.
Discussion of an investigation of the incompatibility of titanium in certain grades of nitrogen tetroxide. The methodology used in the resolution of this problem points out some of the dangers associated with compatibility testing and presents some of the difficulties associated with coordinating an investigation involving many contractors and U.S. government agencies. The techniques employed in this investigation are described in detail. M.F.

A67-42007
MICROBES AND THEIR JET FUEL ENVIRONMENT.
William B. Engel and Richard F. Hazelton (McDonnell Douglas Corp., Douglas Aircraft Co., Aircraft Div., Santa Monica, Calif.).
Society of Automotive Engineers, Aeronautic and Space Engineering and Manufacturing Meeting, Los Angeles, Calif., Oct. 2-6, 1967, Paper 670869. 13 p. 13 refs.
Members, $0.75; nonmembers, $1.00.
DC-8 aircraft fuel tank sump drainings and soil, air, and fuel-water samples from fuel distribution facilities were analyzed for microbial contamination. The data were evaluated to determine the fuel tank contamination, its sources, and its effect upon the aircraft so that corrosion prevention methods could be developed. Sampling plans and microbial examination techniques are presented. Principal contaminants were Hormodendrum resinae, Candida sp., and yeastlike cells. They appeared together in many aircraft. Most of the microorganisms found in aircraft samples were also found in samples from fuel distribution facilities, but only in very low frequency in aircraft dispensed fuel. The fuel facilities could serve as an important microbial source when the final barrier is breached or not effective. (Author)

A67-42018
RELIABILITY OF THE SST WING-SWEEP ACTUATION SYSTEM.
G. C. Newell and F. E. Marsh (Boeing Co., Commercial Airplane Div., SST Branch, Seattle, Wash.).
Society of Automotive Engineers, Aeronautic and Space Engineering and Manufacturing Meeting, Los Angeles, Calif., Oct. 2-6, 1967, Paper 670884. 11 p.
Members, $0.75; nonmembers, $1.00.
Description of the reliability aspects of the wing-sweep actuation system for the Boeing SST in terms of: (1) the hardware interfaces, functional purposes, and basic design concepts; (2) the basic requirements and design criteria established by certain Federal agencies; (3) Boeing-evaluated airline economic goals; and (4) reliability analyses relating the hardware design to specific requirements. It is pointed out that the full-size wing-pivot bearing has been tested to 30,106 cycles without malfunction. R.B.S.

A67-42077
ENVIRONMENTAL CONDITIONS FOR ADVANCED FASTENER SYSTEMS.
R. J. Lingscheid (North American Aviation, Inc., Rocketdyne Div., Canoga Park, Calif.).
IN: ADVANCED FASTENERS; SOCIETY OF AUTOMOTIVE ENGINEERS, AERONAUTIC AND SPACE ENGINEERING AND MANUFACTURING MEETING, LOS ANGELES, CALIF., OCTOBER 2-6, 1967, PAPERS. [A67-42076 24-15]
New York, Society of Automotive Engineers, Inc. (SAE SP-293), 1967, p. 1-12. 5 refs.
Examination of some basic guidelines for the selection of a fastener system intended for use in an exotic environment which will subject the fastening system to unusual stress conditions. Recommendations for material selection are made, guidelines which engineers and designers may follow in the pursuit of design allowables are given, and problems associated with the operation of fasteners in cryogenic environments are discussed. R.B.S.

A67-42329 #
FRACTURE TOUGHNESS AND STRESS-CORROSION CRACKING OF SOME TITANIUM ALLOY WELDMENTS.
R. W. Huber, R. J. Goode, and R. W. Judy, Jr. (U.S. Navy, Office of Naval Research, Naval Research Laboratory, Metallurgy Div., Washington, D.C.).
(American Welding Society, National Fall Meeting, Houston, Tex., Oct. 2-5, 1967, Paper.)
Welding Journal, Research Supplement, vol. 46, Oct. 1967, p. 439-s to 447-s. 10 refs.
Navy-ARPA-supported research.
Determination of fracture toughness and stress-corrosion cracking characteristics for a variety of 1-in.-thick titanium alloy plates and welds. The drop-weight tear test (DWTT) and a bend bar K_{Ic} test were used in the fracture toughness studies. A precracked cantilever band specimen was used for the stress-corrosion cracking studies. The results of a study on the stress-corrosion cracking resistance of as-deposited and heat-treated gas metal-arc welds and as-deposited electron-beam welds in water containing 3.5% NaCl were compared to those obtained for the base metal. The critical stress intensity parameter for stress-corrosion cracking to occur, K_{Iscc}, was determined for as-deposited and heat-treated gas metal-arc welds and as-deposited electron-beam welds in water containing 3.5% NaCl. The results indicate that for many alloys considerable differences in resistance can be expected between the base metal and the weldment. P.v.T.

A67-42484 #
HIGH-TEMPERATURE OILS AND LIQUIDS FOR TURBOJET AVIATION [VYSOKOTEMPERATURNYE MASLA I ZHIDKOSTI DLIA TURBOREAKTIVNOI·AVIATSII].
T. M. Komissarova (Vsesoiuznyi Nauchno-Issledovatel'skii Institut Neftianoi Promyshlennosti, Moscow, USSR).
Khimiia i Tekhnologiia Topliv i Masel, vol. 12, Oct. 1967, p. 18-21. 15 refs. In Russian.
Survey of the synthetic lubricants which correspond to the specification Mil-l-7808 used in the United States in turbojet engines and are required to withstand temperatures on the order of 150°C. Also examined are lubricants corresponding to the specifications Mil-l-9236B (for engine temperatures ranging from -53 to +204°C) and lubricants corresponding to the specification Mil-l-27502 (for engine temperatures up to 260°C). The effect of temperature on the thermal stability of lubricants is examined. V.P.

A67-42519 *
SEALED CELLS AND AUXILIARY ELECTRODES.
H. N. Seiger and S. Lerner (Gulton Industries, Inc., Metuchen, N.J.).
IN: ADVANCES IN ENERGY CONVERSION ENGINEERING; AMERICAN SOCIETY OF MECHANICAL ENGINEERS, INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, MIAMI BEACH, FLA., AUGUST 13-17, 1967, PAPERS. [A67-42485 24-03]
New York, American Society of Mechanical Engineers, 1967, p. 353-356. 14 refs.
Contract No. NAS 5-10241.
The use of auxiliary electrodes in primary and alkaline secondary batteries is discussed. Consideration is given to their use as charge control and scavenger electrodes. The use of these electrodes enhances the electrochemical properties of the cells in which they are placed. These electrodes are leading to leak-proof dry cells and enhanced overcharge capabilities in Ag-Cd cells. Specific reference is made to the Ni-Cd system where the use of auxiliary electrodes leads to long-term, high rate cycling at deep depths of discharge. (Author)

\67-42566 #
THE MAGNETOHYDRODYNAMIC THRUST BEARING.
E. Roland Maki, Dennis C. Kuzma (General Motors Corp., Research Laboratories, Warren, Mich.), and Russell J. Donnelly (Chicago, University, Chicago, Ill.).
Journal of Fluid Mechanics, vol. 30, Oct. 17, 1967, p. 83-95.
refs.
NSF Grant No. GP-2693; Grant No. AF AFOSR-785-65.

The MHD lubrication flow in a step-type thrust bearing has been investigated both theoretically and experimentally. The experimental configuration consisted of nine identical segments arranged in a circular plate. Flow was induced by rotating the upper plate. Pressures, voltages, and torques were recorded. Provision was made for passing current radially through the segments, and it was shown that the torque could be reduced to zero and even reversed by this means. Good agreement has been obtained between the analysis and the experimental results. (Author)

\67-42671 #
ASYMPTOTIC METHODS FOR AN INFINITELY LONG SLIDER QUEEZE-FILM BEARING.
.. C. DiPrima (Rensselaer Polytechnic Institute, Troy, N.Y.).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Chicago, Ill., Oct. 17-19, 1967, ASME Paper 67-Lub-7. 11 p. 18 refs.
Members, $0.75; nonmembers, $1.50.
Navy-supported research.

The application of the techniques of singular perturbation theory (boundary-layer theory) to several problems in gas bearing lubrication is discussed. The leading terms in asymptotic expansions for the pressure are obtained for the cases of (1) a slider bearing with large bearing number, (2) a squeeze-film thrust bearing with large squeeze number, and (3) a combined slider squeeze-film bearing with large bearing number and/or large squeeze number. For the latter problem it is necessary to distinguish several cases depending upon the relative rate at which the bearing number and squeeze number approach infinity. (Author)

67-42672 #
STABILITY CONSIDERATIONS FOR A GAS-LUBRICATED TILTING-PAD JOURNAL BEARING. I.
.. Y. Chu, J. T. McCabe (Franklin Institute, Research Laboratories, Philadelphia, Pa.), and H. G. Elrod (Columbia University, New York, N.Y.).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Chicago, Ill., Oct. 17-19, 1967, ASME Paper 67-Lub-8. 11 p. 6 refs.
Members, $0.75; nonmembers, $1.50.
Contract No. DA-31-124-ARO(D)-147.

The multiplicity of parameters associated with a tilting-pad journal bearing demands that special consideration be given to the selection of an analytical method for stability prediction. The classical Frequency Response (small perturbation) method and the nonlinear Orbit method (a direct numerical integration of all governing differential equations) are discussed and evaluated. A new approach for the determination of film response called the "Step-Jump" method is here extended to the tilting-pad bearing. Three means of utilizing the film response functions in the dynamical equations are outlined and compared. The relationship of the Frequency Response method to the Step-Jump method is explained and a comparison of the Step-Jump results with the Nonlinear Orbit approach is made. One of the techniques for applying the Step-Jump response functions, called the "Characteristic Equation" method, is shown to be most suitable for parametric studies of stability thresholds. (Author)

67-42677 #
SEMI-IMPLICIT NUMERICAL METHODS FOR TREATING THE TIME-TRANSIENT GAS-LUBRICATION EQUATION.
V. Castelli (Columbia University, New York, N.Y.) and C. H. Stevenson (Mechanical Technology, Inc., Latham, N.Y.).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Chicago, Ill., Oct. 17-19, 1967, ASME Paper 67-Lub-18. 4 p.
Members, $0.75; nonmembers, $1.50.
Contract No. Nonr-3730(00).

Description of a numerical method for treating the time-transient Reynolds' equation which combines the numerical stability properties of implicit methods and the speed of execution of explicit methods. The advantages of this method make it suitable for both steady-state and transient calculations. M.F.

A67-42678 #
THE ROLE OF LUBRICATION IN PROPAGATION OF CONTACT FATIGUE CRACKS.
W. E. Littmann, R. L. Widner (Timken Roller Bearing Co., Research Div., Canton, Ohio), J. O. Wolfe (Timken Roller Bearing Co., Steel and Tube Div., Metallurgical Dept., Canton, Ohio), and J. D. Stover (Timken Roller Bearing Co., Physical Laboratories, Canton, Ohio).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Chicago, Ill., Oct. 17-19, 1967, ASME Paper 67-Lub-20. 12 p. 13 refs.
Members, $0.75; nonmembers, $1.50.

Comparative life tests of tapered roller bearings in mineral oils and synthetic fluids, Mil L-7808-F and Mil L-23699, demonstrate a strong influence of lubrication on bearing life and failure characteristics. The inclusion origin mode of failure propagates very rapidly and takes on the macroscopic appearance of the point surface origin mode when fatigue cracks interact with a lubricant having low viscosity at the operating temperature. Observations indicate that bruises from debris in the lubricant are stress raisers of severity equivalent to nonmetallic inclusions in bearing materials for nucleation of contact fatigue cracking. Surface fatigue by "peeling" or superficial pitting can also act as the nucleus of fatigue cracks which propagate in the same manner as the point surface origin mode. In general, any surface stress concentration in combination with low lubricant film thickness promotes surface origin modes of contact fatigue, and low lubricant viscosity at the operating temperature promotes rapid propagation by a hydraulic pressure mechanism. (Author)

A67-42679 * #
EVALUATION OF LUBRICANTS FOR HIGH-TEMPERATURE BALL BEARING APPLICATIONS.
R. J. Parker, E. V. Zaretsky (NASA, Lewis Research Center, Cleveland, Ohio), and E. N. Bamberger (General Electric Co., Cincinnati, Ohio).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Chicago, Ill., Oct. 17-19, 1967, ASME Paper 67-Lub-21. 7 p. 9 refs.
Members, $0.75; nonmembers, $1.50.

Several lubricants that are considered candidates for ball-bearing applications in the temperature range of 500 to 700°F were investigated in full-scale ball bearings and in a rolling-contact fatigue rig. Bearing endurance tests indicate that a synthetic paraffinic oil with an antiwear additive can perform beyond catalog rating at temperatures up to 600°F in a low oxygen environment. In a rolling-contact fatigue tester, this synthetic paraffinic oil exhibited at least twice the fatigue life at the 10% level of a fluorocarbon and a polyphenyl ether. Based on bearing race groove appearance, elastohydrodynamic lubrication was apparent at outer-race temperatures up to 700°F. (Author)

A67-42682 #
EFFECTS OF VISCOELASTIC LUBRICANT ON SQUEEZE FILM LUBRICATION BETWEEN IMPINGING SPHERES.

V. C. Mow (Rensselaer Polytechnic Institute, Troy, N.Y.).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Chicago, Ill., Oct. 17-19, 1967, ASME Paper 67-Lub-24. 4 p. 5 refs.
Members, $0.75; nonmembers, $1.50.
Contract No. N-00014-66-C0037.

Asymptotic solution for squeeze film flow between impinging spheres. The lubricant is assumed to be a four-constant, nonlinear, viscoelastic liquid. The pressure peak in the lubricant is very sensitive to the values of viscoelastic constants. The theoretical results agree qualitatively with those observed experimentally.
M.F.

A67-42685 #
EFFECTS OF LUBRICANTS, METALS, TEMPERATURE, AND ATMOSPHERIC ENVIRONMENTS ON GEAR LOAD-CARRYING CAPACITY.
B. B. Baber, E. L. Anderson, and P. M. Ku (Southwest Research Institute, San Antonio, Tex.).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Chicago, Ill., Oct. 17-19, 1967, ASME Paper 67-Lub-27. 8 p. 11 refs.
Members, $0.75; nonmembers, $1.50.
Contract No. AF 33(615)-2384.

Experimental gear load-carrying capacity results are presented for three different gear materials and a variety of lubricants of different chemical classes and viscosities, with emphasis on high-temperature operation in air and nitrogen environments. The lubricant-metal-atmosphere interaction was found to be complex and could not be predicted by simple means. With a given gear material in an air environment, load-carrying capacity was found to decrease with increasing temperature until a minimum value was reached, and then to increase with further increase in temperature. A substantial reduction in load-carrying capacity was noted when the air environment was replaced with nitrogen. In addition, the increase in load-carrying capacity noted at high temperatures in air environment was not observed when nitrogen environment was used. This general behavior was, however, quite different when another gear material was used. (Author)

A67-42743 #
THE ROLE OF DIFFUSION IN CORROSIVE WEAR.
F. F. Tao (Esso Research and Engineering Co., Linden, N.J.).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Chicago, Ill., Oct. 17-19, 1967, ASLE Paper 67 LC-4. 10 p. 23 refs.
Members, $0.75; nonmembers, $1.50.
Contract No. AF 33(615)-2828.

Examination of the diffusion of oxygen through the lubricant to the metal surface as a contributing factor in corrosive wear. Experimental data obtained for a ball-on-cylinder device are quantitatively correlated with the consumption of oxygen as determined by a mathematical analysis based on the oxygen diffusion to the rubbing surface. The analysis indicates two limits of mass diffusivity: (1) a lower limit (about 3×10^{-8} cm^2/sec), below which corrosive wear is negligible because diffusion is negligible; and (2) an upper limit (1×10^{-6} cm^2/sec), above which the corrosive wear becomes asymptotic because diffusion is complete. Within these two limits the wear is dependent upon the mass diffusivity. The average clearance between the two sliding surfaces predicted from this analysis is of a reasonable order of magnitude to ensure the feasibility of the mathematical model. Experimental data in agreement with theory show that wear increases with oxygen concentration and sliding speed.
T.M.

A67-42745 #
CHEMICAL INTERACTIONS INVOLVED IN THE FORMATION OF OXIDATION-RESISTANT SOLID LUBRICANT COMPOSITES.
D. J. Boes (Westinghouse Electric Corp., Aerospace, Defense and Marine Group, Research and Development Center, Research Laboratories, Pittsburgh, Pa.) and B. Chamberlain (Mellon Institute; Carnegie Institute of Technology, Pittsburgh, Pa.).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Chicago, Ill., Oct. 17-19, 1967, ASLE Paper 67 LC-6. 9 p.
Members, $0.75; nonmembers, $1.50.
Contract No. AF 33(615)-2618.

Solid lubricating compacts of tungsten diselenide-gallium alloys are currently under development for use as self-lubricating members in high-speed high-temperature ball bearing systems. The material is of considerable interest due to the fact that it resists oxidation at temperatures three times higher than pure tungsten diselenide. The paper discusses initial studies of the physical and chemical changes that occur in these compacts during a heat-treating cycle required in their fabrication. Speculations regarding the mechanism responsible for their oxidation resistance are presented. (Author)

A67-42747 #
EVALUATION OF LUBRICANTS USING OPTICAL ELASTOHYDRODYNAMICS.
C. A. Foord, W. C. Hammann (London, University, Imperial College of Science and Technology, Dept. of Mechanical Engineering, London, England), and A. Cameron (Monsanto Co., Central Research Dept., St. Louis, Mo.).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Chicago, Ill., Oct. 17-19, 1967, ASLE Paper 67 LC-12. 13 p. 17 refs.
Members, $0.75; nonmembers, $1.50.
Research supported by Rolls-Royce.

A system is described whereby a clear map is obtained of the contact between a metal (steel) ball rolling against a plate glass disk. This is achieved by mounting the disk in an air bearing and coating its surface with a thin layer of chromium that partially reflects the light, allowing good interference patterns to be formed. The effect of load (giving stresses to 100,000 psi) and speed and viscosity is demonstrated for a wide range of fluids. A complete run can be carried out with at most 5 ml of sample. It is shown that load hardly alters the film thickness in the middle of the contact but does affect the minimum film thickness, which is in the side lobes. By using a calibrated oil the pressure-viscosity coefficients of the fluids can be determined. The rate of shear is very high, between 0.1 and 40 million per second and the flow orientation of polymer thickened oils is clearly marked as well as the molecular orientation postulated by Bondi. For most fluids, except the polymer thickened oils and silicones, the fluid structure influences the film thickness primarily through its effect on viscosity and pressure viscosity. (Author)

A67-42748 #
OXIDATION CHARACTERISTICS OF MoS_2 AND OTHER SOLID LUBRICANTS.
Melvin T. Lavik, Thomas M. Medved (Midwest Research Institute, Kansas City, Mo.), and G. David Moore (W. S. Dickey Clay Manufacturing Co., Pittsburg, Kan.).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Chicago, Ill., Oct. 17-19, 1967, ASLE Paper 67 LC-14. 11 p. 19 refs.
Members, $0.75; nonmembers, $1.50.
Contract No. AF 33(657)-10384.

Thermogravimetric oxidation data are presented for 15 refractory metal dichalcogenides. Interpretation of these data is supported by oxidation thermograms of the chalcogens and the refractory metals and by X-ray diffraction analysis of the oxidized products. The effects of humidity, heating rate, and particle size on oxidation of the dichalcogenides are presented. Thermogravimetric analysis is shown to be helpful in detecting impurities, such as unreacted elements, in commercial samples. Some dichalcogenides are shown to retain the same relative oxidation stability, when bonded in thin films with a ceramic, as for pure powder samples. A table is presented summarizing these oxidation characteristics together with information from the literature on crystal structures, electrical resistivities, and densities. (Author)

A67-42749 #
THE LUBRICATING PERFORMANCE OF AN "IN SITU" PROCESS MoS_2 FILM IN AIR AND IN LIQUIDS.
Alfred Di Sapio and James Maloney (Dow Corning Corp., Molykote Plant, Stamford, Conn.).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Chicago, Ill., Oct. 17-19, 1967, ASLE Paper 67 LC-15. 8 p. 15 refs.
Members, $0.75; nonmembers, $1.50.

The performance of a synthetic MoS_2 film, produced by electrodeposition of molybdic oxide followed by a temperature-pressure H_2S conversion to a molybdenum sulfide compound, is examined under extreme pressure conditions immersed in various fluids. Friction, wear, and elastoplastic characteristics, measured on various test machines, are compared to those of the fluids alone and also to conventional bonded films. The fluids examined include mineral oil, jet fuel, hydraulic fluid, silicone fluid. The dry films include burnished MoS_2 powder, MIL-L-8937 resin bonded film, MIL-L-8129 silicate bonded film and the synthetic "in situ" MoS_2 film. The performance of the synthetic MoS_2 film on titanium and stainless steel is also examined. (Author)

A67-42750 #
LUBRICATION OF BEARING STEELS WITH ELECTROPLATED GOLD UNDER HEAVY LOADS.
Riitsu Takagi (Dayton, University, Research Institute, Dayton, Ohio) and Tung Liu (USAF, Systems Command, Research and Technology Div., Materials Laboratory, Wright-Patterson AFB, Ohio).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Chicago, Ill., Oct. 17-19, 1967, ASLE Paper 67 LC-16. 8 p. 8 refs.
Members, $0.75; nonmembers, $1.50.

The lubricating action of electroplated gold on 52100 steel and 440 C stainless steel in sliding under a 68-kg load was examined with a tester consisting of a single rub block loaded against a rotating disk. The advantage obtained with gold plating was that of low wear while the coefficient of sliding friction remained high. The wear life of thick films was much longer; one 20-μ film had a wear life of 150,000 revolutions, while 1-μ films had wear lives of about 3000 revolutions. Silver, copper, and two gold alloys plated to the appropriate thickness were able to extend the wear life to several thousand revolutions while nickel was not effective at all. The failure of the plated films was usually marked by a rapid increase in wear rate. With thick gold alloy films, wear debris in the form of flakes were obtained in addition to irregular shaped particles. The appearance of the wear track indicated that the gold film underwent considerable plastic deformation. (Author)

A67-42751 * #
SOLID FILM LUBRICATION OF WORM GEARS.
Hugh S. Hass (Midwest Research Institute, Kansas City, Mo.).
American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, Chicago, Ill., Oct. 17-19, 1967, ASLE Paper 67 LC-18. 8 p. 8 refs.
Members, $0.75; nonmembers, $1.50.
NASA-supported research.

A study was conducted to determine the feasibility of lubricating worm gears with bonded solid film lubricants. An apparatus for determining gear efficiency and lubricant film wear-life was fabricated. Several tests using conventional oil lubrication were conducted to establish baseline gear efficiency data. Efficiency and wear-life tests were made with four solid lubricant films, two of them incorporating MoS_2 and Sb_2O_3 in organic polyimide resin binders, and two using MoS_2, graphite and gold or bismuth in an aluminum phosphate or sodium silicate binder. Experimental data indicate that solid film lubrication of worm gears is feasible, without a serious loss of efficiency in situations where limited wear-life is acceptable. (Author)

1967
AEROSPACE MEDICINE AND BIOLOGY ABSTRACTS

A67-80634
FIRE AND HYPERBARIC OXYGEN.
D. M. Denison, J. Ernsting, A. W. Cresswell (Roy. AF Inst. of Aviation Med., Farnborough, Great Britain).
(Second Intern. Congr. on Res. in Burns, Edinburgh, 1965). *Lancet*, vol. 2, Dec. 24, 1966, p. 1404–1405. 11 refs.

Little is known of the fire-risks to man in oxygen-rich environments such as those obtained with hyperbaric oxygen therapy. Experimental evidence shows that the risks of ignition and the subsequent burning-rate are strikingly increased when compared with normal conditions. The risk of ignition will be further increased as more equipment fitted with electronic instruments is brought into use and by grease or petrol stained clothing. The fires are more serious because of the high burning-rate. Established methods of fire extinction are ineffective under these conditions. Some precautions have already been urged but others might include: administration of hyperbaric oxygen by oronasal tube whenever possible; replacement of a patient's clothing by a tight-fitting, fireproofed garment; and the incorporation of an automatic flame-detector and suitable water supply into the system.

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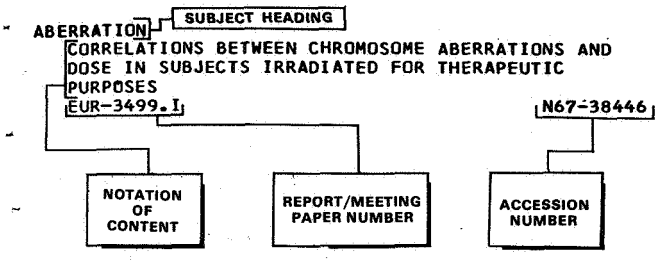

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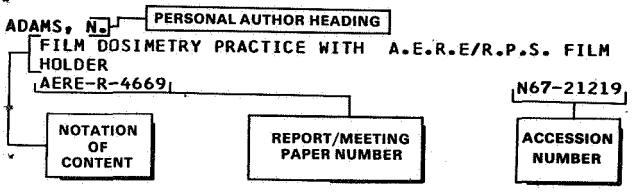

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